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AN EXAMPLE OF RAPID STEEL ERECTION.

The accompanying photographs show two stages in the erection of a pier shed with steel frame on Pier 8, East River, New York City. The building has a steel frame which is covered on the sides, ends and gables with galvanized corrugated iron. The steel frame is made up of 27 bents and trusses of the type shown in Fig. 2, spaced 20 ft. c. to c., and two end trusses as shown in Fig. 1. The roof trusses and second floor are supported on I-beam columns and built-up floor beams. The dimensions of the structure are:

Length out to out columns	about 545 ft.
Width out to out columns	56 ft. 8 ins.
Height to second floor	20 ft. 0 ins
Height second floor to trusses	10 ft. 0 ins.
Slope of roof per ft.	4⅜ ins.
Total amount of steel	350 tons.

The first photograph (Fig. 1) was taken the day erection was commenced, Nov. 21; the second was taken Dec. 4, and shows the steel work as complete, although about one-fourth of the riveting at that time still remained to be finished. A total of 14 calendar days intervened between the two dates, but there must be deducted two Sundays, two Saturday half-holidays, Thanksgiving Day and one rainy day on none of which was work done. This leaves a total of 9 working days, a remarkable record of rapid erection. The erection was effected by an average force of about 50 men working an eight-hour day. Pneumatic riveters were used and the handling was done by the traveler shown in Fig. 1, moving on rollers and controlled from the hoisting engine shown.

The work was executed for the "Compania Transatlantica" by John Monks & Sons, contractors, 82 Beaver St., N. Y. City. Mr. J. W. Ripley was the engineer for the contractors.

METHODS OF REMEDYING THE INTERFERENCE OF FOREIGN CURRENT WITH AUTOMATIC BLOCK SIGNALS.

The rapid development of electric interurban railways and the multiplication of crossings of electric with steam railways has introduced a serious difficulty on steam railways using the automatic block signal system with rail circuits, due to the effects of the return current upon the signals. At the annual meeting of the Railway Signal Association in October, 1905, it was decided that the attention of general managers ought to be called to the seriousness of the situation and to the desirability of making the electric railways responsible for interference of foreign currents with the signals of the steam roads. A committee was appointed to take up this subject and also to propose a resolution to be introduced in State Legislatures which would give the steam road power to demand that an electric road wishing to establish a crossing should adopt such methods of construction as would ensure that the safe and proper operation of the signals would not be affected by currents from the electric road. The report of this committee was presented at the recent annual meeting of the association.

A large part of the report is composed of summaries of replies to a list of questions sent out in a circular, and in a majority of cases the replies are too general to be of much real value. As to the remedies to be provided, some suggest the prohibition of ground returns, while others believe that this prohibition (while it would be effective) is not possible. Some consider that electric railways should be required by State laws to eliminate all ground currents, while others consider that such a step would not be wise. A few of the more complete and definite replies as to methods of overcoming the effects of foreign current are given below:

1. Use storage battery supply and arrange polarity to have battery current flow in same direction as foreign current.

2. Insulate steam road rails by removing ballast, using good insulated joints and keeping bonding in first-class condition; also, by insulating one rail and keeping this rail perfectly insulated, allowing other rail to carry leaking current of electric road.

3. Require electric lines to use metallic return with double trolley or at least good copper return connected at short distances to their rails.

4. Equalize resistance of both rails of circuit and arrange polarity of battery current.

5. The best means for overcoming foreign current in a signal track section, especially if it is polarized, is to well drain the roadbed, have the rails free from ballast, have the track insulations in perfect condition with short dead sections on siding or crossings. If they conduct the foreign current, transpose the track circuit at point of greatest amount of foreign current if its potential is higher on one rail than the other. If this does not overcome its effects, put in cut sections with battery open and track shunted when relays open.

6. Study the conditions and obtain exact information as to source, direction, amount and pressure of foreign current and then make rational provision for either removing or blocking this current or allowing it to proceed on the railway company's rails.

7. Have lately heard of several cases, found by trial, where 5-ohm relays have picked up after rear of train had passed a joint (in each circuit tested) from which the bond wires had been removed; the splice bars were on and bolts as tight as usual on good main-line track. Have no doubt foreign current from electric roads caused this; apparently the undue resistance through the splice bars of joint from which wires had been removed set up a sufficient difference of potential between rails to pick up the relay. It was found that a 9-ohm relay, substituted for the 5-ohm relays in each test, would not pick up but, of course, the margin must have been very small and, under other conditions, a 9-ohm relay might

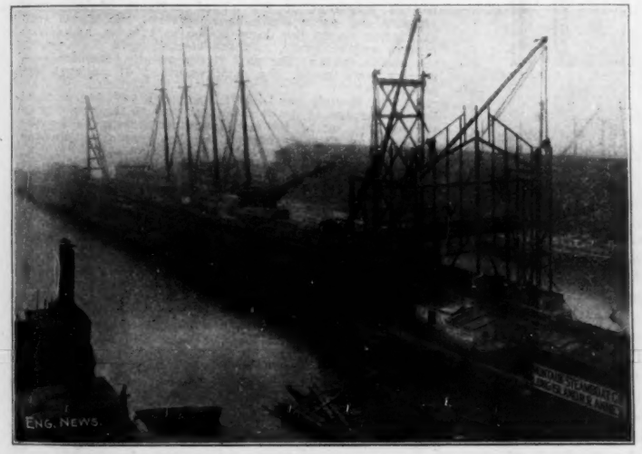

FIG. 1. STEELWORK STARTED NOV. 21, 1906.

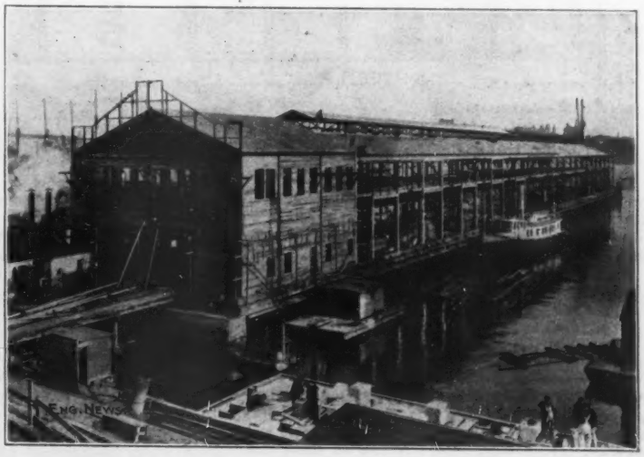

FIG. 2. STEELWORK FINISHED DEC. 4, 1906.

(Five days in which work was not carried on, leaving 9 actual 8-hour days.)

AN EXAMPLE OF RAPID STEEL ERECTION: CONSTRUCTION OF SHED AT PIER 8, EAST RIVER, NEW YORK CITY.

ground, the rubber and other insulations be kept in first-class condition, and the common wire limited to a length of ten miles.

4. For multiple arrangement of track circuit relays, a resistance of 16 ohms is suggested for relay at battery end and 4 ohms for the relay at the other end of track circuit. The committee recommends that further research be made to establish the proper relation of the resistance, pick-up and releasing point of the two relays of the multiple track circuit arrangement.

5. For track circuits having but one relay, a resistance of 9 ohms is recommended for circuits 500 ft. and under, and a resistance of 4 ohms for circuits of greater length than 500 ft. While it is recognized that the best results are to be obtained by using a relay having a resistance proportioned to the resistance of the circuit, the benefits do not compensate for the disadvantage, from a maintenance standpoint, of having to keep in stock track relays of a number of different resistances.

6. It is advisable to thickly coat with a heavy oil the parts of an insulated joint before the joint is put in place. If there is interference from foreign current it is advisable to put a heavy oil on the joint and particularly around the exposed ends of the fiber at least every two months.

7. For direct current track circuit connections run in trunking, No. 8 or larger B. S. gage soft-drawn copper wire with $^{5}/_{32}$-in. rubber insulation wall is recommended.

8. For signal circuit connections run in trunking a No. 12 or larger B. & S. gage, soft-drawn copper wire with $^{2}/_{64}$-in. rubber insulation wall is recommended.

9. Trunking when run parallel with the track should be kept clear of the ground. When run across tracks, trunking should be put in with top clear of the ballast and with top of capping not less than ½-in. below bottom of rail.

10. The standard ground should be made by burying in moist earth an annealed copper plate $^{1}/_{16}$-in. thick, 2 ft. square, to which has been brazed for a length of 12 ins. a No. 4 B. & S. gage soft-drawn bare copper wire. The plate to be buried in clay or in a 6-in. layer of fine charcoal and the connecting wire is not to exceed 150 ft. in length. The effectiveness of the ground should be tested by a Wheatstone bridge.

THE POSSIBILITY OF THE PERMANENT RECLAMATION OF TULARE LAKE BASIN, CALIFORNIA.

By Charles H. Lee.*

A very interesting problem in the reclamation of overflow land, involving engineering features of a broad nature, is that which has recently been presented by the unexpected flooding of the old basin of Tulare Lake, California. Forty years ago the lake was one of considerable size, covering an area of several hundred square miles and having a maximum depth of about 30 ft. A long series of dry years, combined with increased use for irrigation of the water which formerly reached the lake, resulted in a gradual contraction of the shore line, until in 1898 nothing remained but a few sections of swamp land. The exceptional fertility of the lake bottom soil was recognized soon after the water began to recede. Reclamation districts were formed under the provisions of the California State law and large areas were leveed and planted to crops. In the fall of 1905, the lake bed was absolutely dry and 200 square miles of wheat and barley were planted. A late snowfall in the Sierra Nevada Mts. caused an unusually large stream flow into the lake basin and within three months the whole area was under water, totally ruining a fine stand of grain and causing a financial loss of $5,000,000. The people interested still have hopes of ultimate success in reclamation and many schemes have been proposed, some to alleviate the present state of affairs, and others aimed at the prevention of its recurrence in the future.

The following facts were gathered by the author while employed as assistant in the Hydrographic Branch of the U. S. Geological Survey:

The San Joaquin Valley, in which Tulare Lake is situated, lies between two parallel ranges of mountains, the Sierra Nevada on the east and the Mt. Diablo Range on the west. Its length is about 250 miles and its average width 50 miles. From the foot of each range broad flat plains slope gradually down to the valley trough, which extends with marked regularity throughout the whole length of the valley. All drainage lines entering from the mountains on either side meet this trough at right angles and the latter forms the main drainage system of the valley and, under the name of the San Joaquin River, collects and carries all surface water to San Francisco Bay except that which is held by the Tulare and Buena Vista Basins. Due to the fact that the streams draining the Sierras have perennial flow and are much more active in carrying and depositing detrital material, the east side plain has been built out beyond the geographical axis of the valley, and the trough is situated comparatively close to the foot of the Coast Range. This process has been carried on to a greater extent at the mouth of Kings River than anywhere else. A wide flat alluvial fan whose toe reaches up onto the west side slope has been pushed out across the valley. A natural dam is thus formed which impounds all water entering the valley from the south and creates the body of water known as Tulare Lake.

The general shape of the lake basin (Fig. 1) is that of a shallow saucer of irregular outline. An area of 55 square miles in the center is almost flat, not varying by more than 1 ft. from an elevation of 180 ft. above mean sea level.* Thirty-five square miles lying in the form of a ring around this level area have an average elevation of 182 ft. and an outer ring of 40 square miles averages 184 ft. in elevation. Both of these rings are widest south and east of the center. Beyond this the slope increases more rapidly, especially on the north and west sides of the lake. The elevation of the lowest point in the saddle on the ridge to the north of the lake is 207 ft. The confined water has no outlet until it overtops this by two or three feet when it flows on down to the San Joaquin River through Summit Lake and the Fresno Swamps. As the lowest elevation in the lake basin is 179.3 ft., the lake will have a maximum depth of about 30 ft. when overflow commences. The area then covered is about 700 square miles. For a depth of 12 ft. the area is 300 square miles and for a depth of 7.5 ft. the area is 200 square miles.

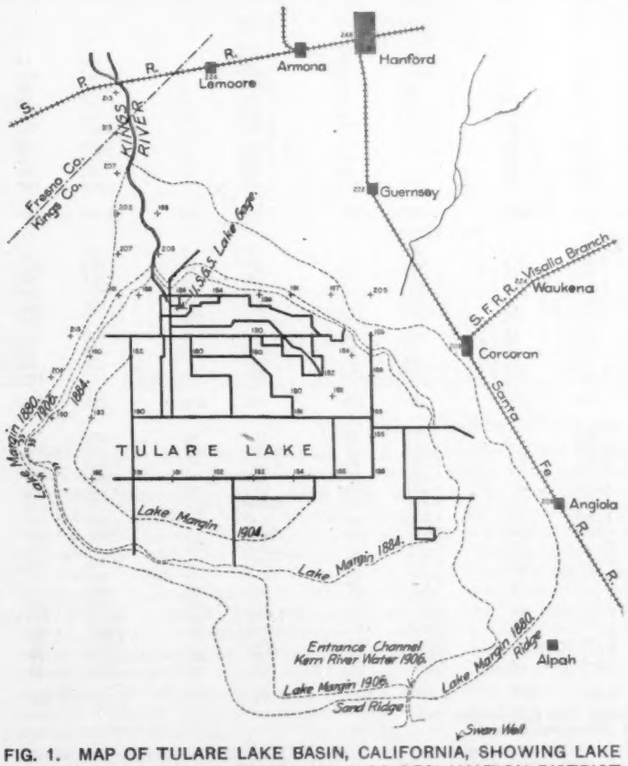

FIG. 1. MAP OF TULARE LAKE BASIN, CALIFORNIA, SHOWING LAKE MARGIN AT VARIOUS TIMES AND ALSO RECLAMATION DISTRICT LEVEES.

(Heavy lines within lake margin indicate levees constructed prior to 1906. Small numbers opposite section corners, etc., are elevations referring to mean sea level, as determined by U. S. Geological Survey. To reduce California State Engineering Department elevations to mean sea level subtract 4.2 ft.)

The principal streams whose discharge reaches the lake are Kings, Kaweah, Tule and Kern rivers. Of these, Kings River deserves the most attention. After leaving its narrow rocky canyon it flows for a short distance over a bed of cobblestones which has about the same elevation as the surrounding country. This is the only place where diversion for irrigating foot-hill land by gravity flow can be made and fullest advantage has been taken of this location. Below here the river enters the Centerville bottoms and remains from 10 to 60 ft. lower than the general surface elevation almost to Kingsburg. Here the real delta begins and the river splits up into several channels, some of which drain into the San Joaquin River and the main one into Tulare Lake. Diversions are easily made on the river below Kingsburg and much of its flow is used for irrigating the rich delta and lake lands. Kaweah River enters the valley about 15 miles south of the Kings River. The main channel loses its identity soon after leaving the foothills and its flow is spread out over a large area of swamp land in numerous sloughs. Most of this delta country is subject to overflow during high water. There are several channels leading from this swamp which discharge into the lake basin, Cross Creek being the largest. Tule River is next south from the Kaweah. It also separates into several channels, but these have been brought under control and the flow into the lake basin is between levees.

Kern River enters the valley 50 miles south of Tule River and its channel does not enter the lake directly. Irrigation development on its delta has advanced to such an extent that the entire flow in medium stages is diverted into ditches and canals. Excess water during flood periods is led into the Buena Vista Reservoir, a natural basin lying to the south of the delta ridge, and drawn upon during low water periods. A large canal leads from the reservoir down the west side of the valley, of sufficient capacity to relieve the reservoir when full and carries excess water to the Buena Vista swamps through which it finds its way to Tulare Lake. The distance from the reservoir to the lake is about 40 miles. It has been many years, however, since the Buena Vista Reservoir has been unable to hold the flood discharge of Kern River. The prevailing winds across Tulare Lake during a large part of the year are from the north and northwest. In past ages they have piled up a ridge of sandy material to a height of 15 to 20 ft. around its south and southeast margin. During the long period in which Kern River did not discharge into the lake its old channel through this ridge was filled up. This caused an interesting condition of affairs in the spring of 1906, which will be referred to later.

Personal observation of lake stage during 1906 and fairly reliable information relative to former years have led to the belief that the usual period during which the lake basin fills comprises the months of April, May, June and July. For convenience this period is spoken of in this article as the "replenishing period," because the supply of water in the lake is then being replenished. Table I. shows mean monthly flows of Kings,

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*All elevations in this article are referred to mean sea level, as determined by the U. S. Geological Survey. To reduce California State Engineering Department elevations to mean sea level, subtract 4.2 ft.

not have been unaffected. This is one of the most serious situations that has come to my knowledge as, if the mere breaking of the bond wires on one joint, may cause a signal failure, the risks seem very great. But it is not clear what remedy is to be applied.

8. After 13 years fighting with foreign currents on automatic signal work, I have been convinced that its harmful effects can be overcome in but two different ways. One way is to insulate the rails of electric roads and steam roads in such manner as will prevent any current leakage to the earth. The other is to use a current for track circuits which will operate a track relay on which direct current will have no effect. The first scheme is not practicable on account of its excessive cost. The second can be applied at a moderate cost, and is entirely reliable.

9. The general manager of a steam road in giving permission to an electric line to cross his road, should require the electric line to put in a good copper return well bonded to the rails to reduce the voltage as much as possible.

10. For overhead lines, the general managers or parties who draw up the agreements for crossings of

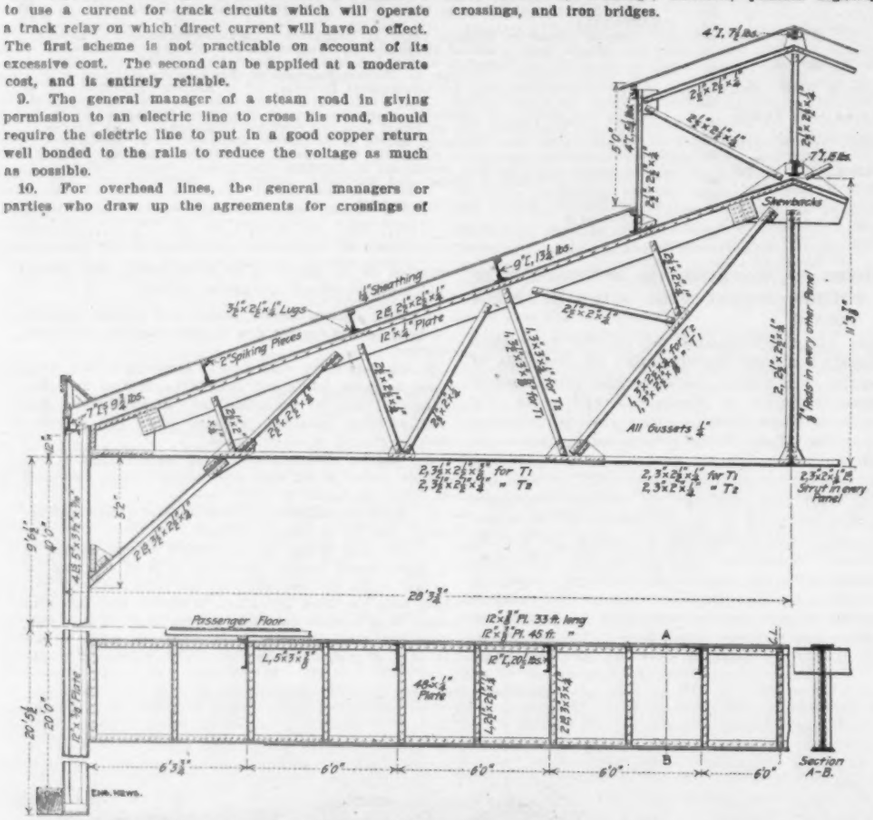

FIG. 3. HALF CROSS-SECTION OF STEEL PIER-SHED FOR PIER 8, EAST RIVER, NEW YORK CITY.

electric and steam lines should be furnished with an outline enumerating the various points which should be covered by the contract, such as clearance of wires from track and from telegraph wires or other structures. All wires carrying over 1,000 volts should be protected by basket or proper netting, etc. The protection which should be followed, or construction of wires which should be carried out, for lines crossing steam lines, should conform to plans furnished by the latter, which plans would specify the detail of such construction. The damage to property or injury to persons on steam lines should be borne by the electric line making the crossing. For tracks there should be required the bonding of electric line, insulation between electric and steam lines, the allowable return current on steam line in minimum volts and amperes, the provision for steam line during necessary work in case electric line does not do it, and clause providing for the responsibility in case of damage to property or persons on steam line on account of current passing from electric to steam line due to improper workmanship or maintenance.

11. The electric roads are grounding a very large amount of current, often at a considerable distance from the power-house. This current will return to the power-house by the paths of least resistances. Since it requires so little current to operate a track relay, it seems to me, in view of the condition in our steam road tracks, it would be practically impossible in a great many cases to bond a track of an electric road so securely that there would not be a small amount of current returning by other routes, a very little of which would play havoc with the steam road signals.

12. Foreign current in track circuit usually follows both rails and not any one particular rail, and I do not think it is possible to connect battery to work in same direction as foreign current, except in rare cases where the conditions are such that foreign current traverses rails in opposite directions.

13. Where a good ground is available, grounding will tend to improve conditions, but a break in the ground connection would probably cause foreign current to act on the relay.

14. The grounding of both sides of a dead section will tend to reduce the trouble locally by equalising the difference of potential. It also reduces the resistance of the foreign current return, which will increase the foreign current flow and may increase the trouble some distance away where the resistance of each side of a track circuit may not be the same.

15. Foreign currents are most likely to enter at electric railway crossings, switches, planked highway crossings, and iron bridges.

16. Since a 1600-ft. track section will "pick up" from 0.5 to 2 amperes from a running stream, it would seem that steam roads which run along a river, as so many do, may expect considerable trouble from stray currents as the lines of the electric roads are extended.

After a careful consideration of the replies and of the subject in general the committee arrived at the conclusion that the recommendations of the Association must be divided into two classes: 1. In regard to precautions to be taken to prevent trouble on a steam road when an electric road is to be allowed to cross it; 2, in regard to methods to be followed in keeping foreign current from interfering with the working of the signals on the steam road when the electric road cannot be made to provide the return conductor.

Under the first class, the association may make recommendations to State legislatures regarding possible legislation and recommendations to general managers regarding the essentials of a form of contract or agreement to be executed concerning the crossing between the electric and the steam road. In regard to recommended legislation, however, the committee reports that it has obtained legal advice to the effect that it is improbable that a State legislature could be persuaded to pass a law calling for the desired protection of the steam road, and probably the best that could be done would be to get a law passed giving the State Railroad Commission power to require the crossing to be made in such a manner as not to interfere with the working of the signals on the steam road. If this should be done, each crossing case would have to be taken up with the State Commission separately, to have the commission rule that the crossing shall be made and protected in the manner covered in the proposed agreement between the two roads. The committee submitted a draft of a law and also certain requirements to be included in an agreement covering the installation, maintenance and use of a crossing by an electric railway. We give below the proposed law and an abstract of the proposed agreement:

A. PROPOSED STATE LAW.—The Board of Railway Commissioners shall, whenever in its judgment the public safety requires the erection of interlocking switch and signal devices at points where steam and electric street surface railways intersect at grade, direct the erection of such interlocking switch and signal devices in such a manner as shall least interfere with the safe operation of the railway whose tracks are crossed, and shall direct that the expenses of such erection shall be borne by the road seeking to make such crossing.

B. PROPOSED AGREEMENT.—1. The electric road agrees that the steam railway may and the steam railway agrees that it will, at the sole cost and expense of the electric road, furnish and at the crossing erect and install in conformity to the plans, specifications and requirements of the signal engineer of the steam railway company, an interlocking plant with derails, machinery, apparatus and appurtenances, as said signal engineer may require, and connect the same with every track of said steam railway then there being, or which should be subsequently there laid.

2. Each track of the electric road must be properly bonded and provided with a 500,000-c. m. return conductor cable which is to be connected to each frog and to each rail of the electric road for a distance of 100 ft. on each side of the tracks of the steam road and shall be connected to the separate return conductor of the electric road if one is used.

3. The return conductor provided by the electric road shall be of such capacity that the potential of the traction return current, when measured between the crossing rails and the track circuit rails of the steam railroad shall not exceed two volts.

4. Insulation of the type and arrangement required by the signal engineer of the steam railway shall be provided by the steam road at the expense of the electric road, between the rails of the crossing frogs and the track circuit rails of the steam railway.

5. All wires of the electric road charged with power currents must be supported in the manner and given the clearance from the tracks, the telegraph, the telephone and the signal wires of the steam railway that is required by the signal engineer of the steam road.

6. Protection nets, bridges or other supports of the design, strength and arrangement required by the signal engineer of the steam road must be supplied by the electric line for all wires charged with current from 500 to 11,000 volts which cross the tracks or wire lines of the steam railway. Nets or bridges are not recommended for power transmission lines charged with current of over 11,000 volts.

7. In case the electric road shall fail to promptly make all repairs and renewals to said return connections, power wires and protection nets or bridges, when in the judgment of the signal engineer of the steam railway the same shall be necessary, the steam road may after giving ten days' notice in writing, make such repairs and renewals, and the electric road shall pay to the steam road at the end of the month in which such repairs were made, the entire amount of all such expenditures.

8. The electric road shall bear and pay any and all loss or damage to its own property, or to the property in its custody, or to its employees or passengers, or the property or the employees or the passengers on the steam railway arising from any defect in said interlocking plant or its appurtenances, said return connections and power wires, or from any act or neglect of its own employees; or arising from any cause, the responsibility for which cannot be determined.

9. All loss or damage to the property or employees of the steam railway, or to persons or property in the charge of the steam road as a carrier or otherwise, which shall arise from or grow out of any act or neglect of the employees of the electric road or shall result from wrong working of automatic and interlocking signals on the steam railway, which it can be shown has occurred through current escaping from the electric road, shall be wholly borne and paid by the said electric road.

Under the second branch of the subject, relating to methods of protection of the signals against interference due to foreign currents, the committee presented the conclusions given below. The conclusions were not adopted, however, the report being accepted as a report of progress and referred back to the committee.

METHODS OF PROTECTION AGAINST FOREIGN CURRENTS.—1. When there is a crossing of an electric road with a steam road, batteries must be placed at each end of steam road track next to crossing, and battery current arranged to flow in direction with foreign current leading into track circuit, if foreign current is found to flow in a definite direction. The connections, through block section for control of signals, must be made by means of line wire circuits. If there is sufficient foreign current to improperly work the track relay when an insulated joint is broken down, the multiple track relay arrangement should be used.

2. For situations where there are power-houses and foreign currents follow the track rails, although there may not be a crossing or connection with an electric road, it is recommended that the conditions be carefully studied and exact information obtained as to the source, direction, amount and pressure of foreign current and provision should then be made for removing or blocking out this current.

3. To minimize as far as possible the effects of foreign current on line wire circuits, it is regarded as important that trunking be kept above the top of the

Kaweah, Tule and Kern rivers during this period for all years when measurements were made and also their relation to the mean for the number of years observed. It indicates conditions in 1906 which are unprecedented during at least 17 years and in all probability during 27 years. Table II. gives the mean yearly discharge in second-feet for these streams above diversion.

Kings River discharges more water into the lake than all other sources combined. The combined average yearly flow of Kaweah, Tule and Kern rivers for the period of record is 1,798 sec.-ft., as compared to 2,427 sec.-ft. for Kings River, or about 75%. Their combined flow into the lake during the period in which the lake was rising in 1906 was 40% of the similar quantity for Kings River. The U. S. Geological Survey* has made measurements which indicate the combined maximum capacity of canals diverting above Kingsburg to be 3,500 sec.-ft., distributed as follows:

Gould Canal	260	sec.-ft.
Church Ditch	1,040	"
'76 Canal	676	"
Centerville & Kingsburg Canal	727	"
Fowler Switch Canal	588	"
Total	3,291	sec.-ft.

These measurements represent maximum capacities in all cases but the '76 Canal, which probably will carry 1,000 sec.-ft. Very little of this water returns to the river. A measurement made July 12, 1906, however, during extreme flood discharge, indicates a possible maximum canal capacity of 4,000 sec.-ft. On that date the Government gage at Red Mountain showed a discharge of 19,000 sec.-ft. At Kingsburg a flow of 15,000 sec.-ft. was measured, giving a difference of 4,000 sec.-ft., most of which was diverted. This value is used in computations involving 1906 data.

Flood flow measurements made during the last two years at Kingsburg and on the lower Kings River below diversion, near its entrance to the lake, show that under flood conditions one-half the total flow at the former place reaches the lake, that part of the remainder which is not diverted for irrigation draining into the San Joaquin River. This ratio changes in medium and low stages, but it is not practicable to determine its exact value. As the diversions below Kingsburg have no direct bearing on this discussion they have not been analyzed.

Kaweah River has a mean yearly flow of 663 sec.-ft., as determined from an eight-year record. All of its water reaches Tulare Lake except that used for irrigation. The combined capacity of canals diverting water is estimated at 2,000 sec.-ft.* Tule River contributes a very small amount and seldom flows into the lake.

The evaporation rate from the lake surface has never been determined by direct observation. During the years 1881 to 1885, however, the State Engineering Department of California† kept a record at Kingsburg, on the Kings River, 30 miles northeast of the lake. Standard evaporation pans were used, one being floated in the river and the other placed on the bank, set into the soil to the depth of the water surface. Table III. gives the average depth of evaporation by months for the period Nov. 1, 1881, to Oct. 31, 1885. The column "pan in air" refers to the pan on the bank. The temperature of the water in this pan agreed very closely with that of the air, and the other with the river water. It seems quite probable that a mean between these two records would represent the evaporation from the surface of the lake. The lake is shallow and its temperature is controlled largely by that of the air, although not to such an extent as the small pan. The river water had a much more uniform temperature than that in the pan in the air and was not affected by local air temperatures. By combining the two records values are obtained which represent neither extreme and probably give a close approximation to the true values.

The continued low stage of the lake from 1898 to 1900, and its absolutely dry condition in the fall of 1905, led to a general belief that a permanent change had taken place in the distribution of water which formerly found its way into the Tulare Basin. There was considerable surprise, therefore, when on Mar. 15, 1906, Kings River broke through the levees at its mouth and began discharging its waters onto the great wheat fields of the lake bottoms. About the same time water from both Kaweah and Tule rivers reached the lake. Although these three streams did not have

*See Water Supply and Irrigation Paper No. 134, U. S. Geological Survey.

*See Water Supply and Irrigation Paper No. 18, page 37.
†See Physical Data and Statistics of California, page 378.

TABLE I.—MONTHLY FLOW ABOVE DIVERSION DURING REPLENISHING PERIOD OF STREAMS ENTERING TULARE LAKE.

Year.	April Disch. in sec.-ft.	April % of mean.	May Disch. in sec.-ft.	May % of mean.	June Disch. in sec.-ft.	June % of mean.	July Disch. in sec.-ft.	July % of mean.	Period Disch. in sec.-ft.	Period % of mean.
Kings River.										
1879.....	4,750	124	5,090	65	3,760	45	1,650	41	3,816	70
1880.....	5,230	137	7,120	91	9,540	104	4,800	120	6,672	113
1881.....	5,800	152	8,220	105	5,010	60	4,790	120	5,955	109
1882.....	3,170	83	9,190	117	6,410	76	2,020	51	5,197	82
1883.....	2,220	58	6,700	85	6,730	80	1,460	37	4,280	65
1884.....	3,370	88	9,210	118	17,630	210	13,210	332	10,855	187
1896.....	1,940	51	5,920	76	12,740	152	3,740	94	6,085	98
1897.....	5,320	139	14,470	185	6,150	73	2,180	65	7,025	115
1898.....	3,550	93	3,540	45	2,120	25	695	17	2,476	45
1899.....	4,510	118	3,570	46	6,080	72	1,410	35	3,892	68
1900.....	2,100	55	5,880	74	5,130	61	1,280	32	3,597	55
1901.....	4,490	118	11,090	141	14,360	158	6,260	157	9,050	143
1902.....	4,100	109	6,530	83	8,060	96	1,640	41	5,097	82
1903.....	3,290	86	9,545	122	7,875	94	1,950	49	5,650	88
1904.....	3,550	93	10,375	132	7,565	90	1,955	49	5,861	91
1905.....	2,730	71	5,885	75	6,450	77	1,860	47	4,231	67
1906.....	4,725	124	10,800	138	17,150	204	16,880	423	12,390	222
Mean	3,820	100	7,830	100	8,397	100	3,985	100	6,007	100
Kaweah River.										
1879.....	867	65	774	37	557	26	124	11	580	34
1880.....	2,352	177	2,786	135	3,900	180	743	66	2,445	144
1881.....	1,393	105	1,238	60	990	46	371	33	998	59
1882.....	1,393	105	2,228	108	929	43	743	66	1,323	78
1883.....	805	60	1,021	49	990	46	402	36	804	47
1884.....	1,548	116	2,847	138	4,271	197	3,497	313	3,091	182
1903.....	....	...	3,100	150	2,750	127	1,283	115	2,378	140
1904.....	968	73	2,054	100	1,052	48	220	20	1,073	63
1905.....	783	59	1,386	67	1,348	62	303	27	955	56
1906.....	1,857	140	3,247	157	4,843	222	3,502	313	3,362	198
Mean	1,329	100	2,068	100	2,163	100	1,119	100	1,701	100
Tule River.										
1879.....	118	19	105	12	350	47	35	8	152	22
1880.....	1,289	210	1,040	118	721	97	350	79	850	127
1881.....	874	142	874	99	437	59	219	49	601	90
1882.....	660	107	1,748	198	660	89	437	98	876	130
1883.....	656	107	874	99	874	118	350	79	688	103
1884.....	874	142	2,185	248	3,059	412	2,622	591	2,185	326
1903.....	447	73	358	41	158	21	38	8	250	37
1904.....	279	45	262	30	74	10	17	4	158	24
1905.....	205	33	313	35	146	20	33	8	174	26
1906.....	736	120	1,064	121	955	129	336	76	773	115
Mean	614	100	882	100	743	100	444	100	671	100
Kern River.										
1879.....	764	54	927	41	971	42	535	44	874	48
1880.....	1,557	109	2,650	119	3,317	144	2,196	180	2,432	135
1881.....	2,288	161	2,362	106	1,890	81	1,126	92	1,916	106
1882.....	1,174	82	1,670	75	1,306	56	726	59	1,219	68
1883.....	1,170	82	1,410	63	1,170	50	940	77	1,172	65
1884.....	1,980	139	5,860	262	9,380	400	5,860	480	5,770	320
1894.....	1,495	105	1,607	72	1,085	47	700	57	1,222	68
1895.....	2,724	192	4,369	195	2,906	125	1,482	121	2,870	159
1896.....	972	68	1,401	63	2,456	106	1,316	108	1,536	85
1897.....	2,914	205	4,580	205	2,309	100	1,006	87	2,702	150
1898.....	710	50	735	33	551	24	244	20	560	31
1899.....	893	63	835	37	1,331	57	489	40	887	49
1900.....	472	33	1,111	50	1,283	55	392	32	814	45
1901.....	1,398	98	3,032	135	3,324	143	1,864	153	2,404	133
1902.....	1,805	127	1,787	80	2,165	93	706	58	1,615	90
1903.....	1,249	88	2,148	96	2,340	101	868	71	1,651	91
1904.....	1,005	71	1,841	82	1,746	75	646	53	1,309	73
1905.....	1,043	73	1,915	86	2,235	96	876	72	1,517	84
Mean	1,423	100	2,236	100	2,320	100	1,221	100	1,802	100

Record 1879-1884 kept by California State Engineering Dept.
Record 1894-1906 kept by U. S. Geological Survey.

TABLE II.—YEARLY FLOW ABOVE DIVERSION OF STREAMS ENTERING TULARE LAKE.

Year.	KINGS Mean. disch. sec.-ft.	KINGS % of 16-yr. mean.	KAWEAH Mean disch. sec.-ft.	KAWEAH % of 8-yr. mean.	TULE Mean disch. sec.-ft.	TULE % of 9-yr. mean.	KERN Mean disch. sec.-ft.	KERN % of 15-yr. mean.
1879.....	1,769	73	315	47	113	32	503	64
1880.....	2,670	110	963	145	548	156	1,271	162
1881.....	2,562	106	549	83	329	94	1,175	150
1882.....	2,107	87	568	85	365	104	646	82
1883.....	1,733	71	375	56	306	87	627	80
1884.....	4,728	194	1,550	234	1,142	326	....	...
1896.....	2,585	106	....	...	....	...	854	109
1897.....	2,933	121	....	...	....	...	1,234	157
1898.....	1,116	46	....	...	....	...	348	44
1899.....	1,795	74	....	...	....	...	468	60
1900.....	1,798	74	....	...	....	...	459	58
1901.....	4,296	176	....	...	....	...	1,216	155
1902.....	2,089	86	....	...	....	...	764	97
1903.....	2,283	94	....	...	149	43	755	96
1904.....	2,586	106	564	85	101	29	679	87
1905.....	1,781	73	421	63	101	29	734	94
Mean	2,427	100	663	100	350	100	785	100

Record 1879 to 1884 kept by California State Engineering Department.
Record 1896 to 1905 kept by U. S. Geological Survey.

TABLE III.—Evaporation in Feet at Kingsburg: Averaged for 4 Years, Nov. 1, 1881, to Oct. 31, 1885.

Month.	Pan in River.	Pan in Air.	Mean. ft.
Nov.	0.176	0.174	0.175
Dec.	.099	.104	.102
Jan.	.066	.081	.074
Feb.	.101	.091	.096
Mar.	.204	.225	.214
Apr.	.213	.286	.250
May	.281	.551	.416
June	.483	.776	.630
July	.628	.904	.766
Aug.	.721	.861	.791
Sept.	.541	.615	.578
Oct.	.339	.289	.314
Total	3.851	4.958	4.404

TABLE IV.—Monthly Discharges Above Diversion of Streams Entering Tulare Lake for 1906 Replenishing Period.

Month.	Kings. acre-feet.	Kaweah. acre-feet.	Tule. acre-feet.
April	281,300	110,310	43,800
May	664,100	199,300	65,420
June	1,020,000	287,670	56,830
July	1,037,900	215,330	20,660
Total	3,003,300	812,610	186,710

a large a discharge during April, there was, nevertheless, sufficient water entering to increase the depth to 5 ft. by May 1, and it was then realized that at least part of the crop was doomed. During May and June a spring freshet of extraordinary size occurred, continuing late into July. The record of actual flow during this time on Kings, Kaweah and Tule rivers is given in Table IV. When the flood was at its height it was found necessary to relieve the Buena Vista Reservoir, and in a few days water from Kern River began backing up behind the sand ridge, forming a second lake. This continued until June 25, when the ridge was overtopped and the water then scoured out a narrow channel for itself. When visited July 24, there was a well-defined channel about ½ mile long and averaging 70 ft. in width, discharging about 2,000 sec.-ft. There was considerable difference in elevation between the two lake surfaces and cutting was still in progress. It is probably safe to say that the mean flow from June 25 to Aug. 1 was 2,500 sec.-ft. With water pouring in from every possible source the basin filled rapidly and by Aug. 1 reached a level which was higher than any since 1884. An accurate gage height record of lake stage was kept from May 17 until the end of August. During May, June and July there was an average rise of 0.1 ft. per day. About Aug. 5, evaporation just balanced inflow. Since that date the water has been slowly receding. The maximum depth (Aug. 5) was 12.5 ft.

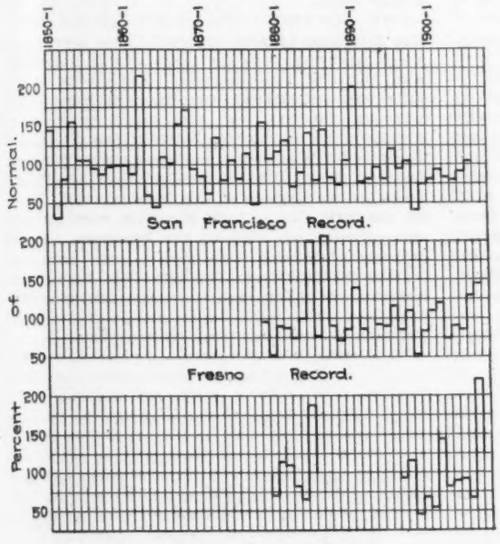

Fig. 2. Ratios of Seasonal Rainfall to Mean Rainfall at San Francisco, 1849-50 to 1905-06, and at Fresno, 1877-8 to 1905-6; Also Similar Ratio for Mean Discharge During Replenishing Period for Kings River, 1879 to 1884 and 1896 to 1906.

Computations from the accompanying map show that on Aug. 5 there was stored in the lake basin 1,028,300 acre-ft. If to this quantity be added 300,000 acre-ft. evaporation loss, a grand total of 1,328,000 acre-ft. is obtained, representing the volume of water entering the lake during the replenishing period. As a check on the above computations the various river discharges from April to July inclusive have been analyzed as follows, using the data of Table IV.

	Acre-feet.
Total discharge Kings River at Red Mountain	3,003,300
Irrigation diversion above Kingsburg	952,300
Total discharge at Kingsburg	2,051,000
Total discharge into Tulare Lake	1,025,000
Total discharge Kaweah River at Three Rivers	812,600
Irrigation diversion	476,100
Total discharge into Tulare Lake	336,500
Total discharge Tule River at McFarland's during April, May and June	166,000
Estimated irrigation diversion	83,000
Total discharge into Tulare Lake	83,000
Total discharge Kern River into Tulare Lake	180,000
Grand total entering lake, April to July, incl.	1,624,000

The question of the future behavior of the lake is a vital one in planning for reclamation. Has the lake during the last few years reached a point in its history where it will dry up permanently or is this low stage one which occurs periodically in obedience to some controlling element? It is believed that the latter condition is nearest the truth. There are many things to support this belief. Mr. C. E. Grunsky, Consulting Engineer, U. S. Reclamation Service, reports* finding at an elevation of 196 ft. a group of one hundred willow stumps on the northern shore line of the lake in 1882, soon after they were uncovered by the receding water. These stumps were apparently the remains of a large grove of trees, some of which had reached a diameter of 4 ft. They had probably grown during a rather low stage and been submerged by a subsequent rise in the water surface. There must, therefore, have been a long period previous to 1882 when the lake stage was low. Indian tradition supports this conclusion. The fluctuation from 1850 to 1906 is shown in Fig. 3, which was largely prepared from data published by Mr. C. E. Grunsky†, being reduced to the datum plane of mean sea level and brought down to date by the author. The diagram covers part of a high stage and the transition to a very low stage. The sudden drop of the lake level noticeable during the years 1879 to 1883, and the subsequent low stage, have often been ascribed to the diversion of water for irrigation which commenced on a large scale about that time. Although this had some influence there is good reason to believe that the rainfall and resulting run-off is the controlling element. Fig. 2 shows graphically for each season the ratio of the total seasonal rainfall to the mean for a long term of years at San Francisco and at Fresno, and also a similar ratio for the mean yearly discharge of Kings River. Neither of the former represent the actual conditions on the drainage area tributary to Tulare Lake, but the general variation from year to year is similar and is worthy of study. It will be noticed that during the period 1850 to 1878 seasons of abnormally high precipitation occurred frequently. On the other hand, seasons from 1879 to 1898 are characterized by low precipitation, there being few above normal after 1885. The Fresno record, which probably best represents conditions in the Kings River basin, indicates a reason for the rapid subsidence from 1878 to 1882, every year being below normal. There seems to be good reason, therefore, to believe that the lake is not naturally a permanent body of water, and that the low stages would have occurred during the last few years, even without the aid of irrigation. There is also no reason to suppose that, if left to itself, the lake will not return to its size of 1850 to 1878 should a series of years of abnormally high rainfall occur, unless provision is made for disposal of the flood water outside of the lake basin.

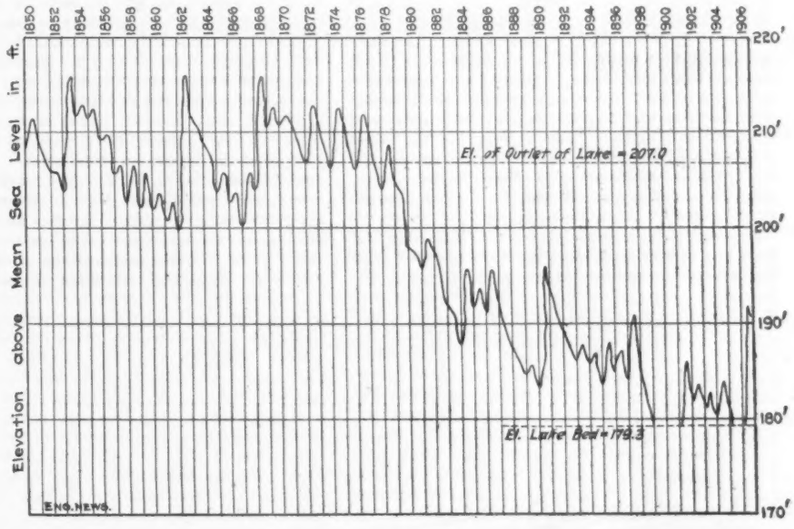

FIG. 3. FLUCTUATIONS IN DEPTH OF TULARE LAKE, 1850 TO 1906.

There has been no attempt in the recent development of the lake bottom as farming land to provide permanently against inundation. The land has been in the possession of the State since 1884, and has been disposed of under the loose terms of the State Reclamation law. This gives full title to prospective purchasers who organize reclamation districts and levee the district boundaries. Many have complied with the letter of the law with the sole purpose of obtaining large tracts of land for speculative purposes. This was carried on to such an extent that even the natural channel of Kings River was enclosed and several levees built across it. The levees were constructed in a hasty manner by throwing up the light lake soil into low ridges without any attempt to protect the wet face from wave action. Most of this work was done during 1903, 1904 and 1905, when the lake was at a very low stage and the land was not in immediate danger of overflow. The spring freshets of 1906 completely destroyed all of these reclamation levees.

As soon as it was realized that there was no possibility of holding back the advancing water, schemes for its disposal were discussed. It was often said that the evaporation would lower the lake level sufficiently within a year so that all but a small portion of the basin could be farmed. A glance at Table III. shows that with no further discharge into the lake it will take from 2½ to 3 years for the water in the basin Aug. 5, 1906, to evaporate. As there is every reason to expect that additional water will enter the lake during the next few years, the futility of waiting for evaporation to dry up the basin is seen. Either drainage or pumping would be very expensive and would relieve the situation only temporarily. To drain the lake a canal would have to be constructed through the Kings River delta. Should grade leave the lake basin at an elevation of 186 ft. its length would be 30 miles; if at an elevation of 180 ft., 40 miles. The first case would require a 20-ft. cut for a large part of the distance, and the second a 25-ft. cut. The cost would probably amount to a million or a million and a half dollars.

The real problem which has to be solved in rendering the lake bottom lands available for permanent farming is not the drainage of the Tulare basin, but the disposal of excess waters outside of the basin where they will do the least harm. Specifically, this means the disposal of flood waters of Kings River in years like 1884 and 1906, since flood waters can be controlled by storage on the other streams. In the first place the overflow from Buena Vista Reservoir can be impounded south of the lake by building up the barrier already formed by the sand ridge. The

*See Water Supply and Irrigation Paper No. 17.
†Bulletin 100, Irrigation Investigations of U. S. Department of Agriculture.

As noted above, the traverse coincides with the property line as much as possible, as between 322, 323 and 325, Fig. 2, but it is not always possible or desirable to do it. In this case the traverse runs off to one side from 307 to 321 and to 322, the bearing and distance of the course being computed after the traverse is adjusted. Sometimes the corner could not be occupied; in such instances, the traverse ran over the point and beyond, as illustrated in Fig. 3. In case it was quite impossible to incorporate a property corner in the traverse, the traverse point was placed as near as possible and a side shot (azimuth and distance) taken to it, as in Fig. 4.

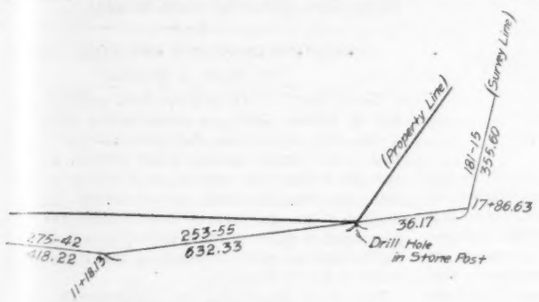

FIG. 3. SKETCH SHOWING THE POSITION OF THE TRAVERSE WHERE THE CORNER COULD NOT BE OCCUPIED.

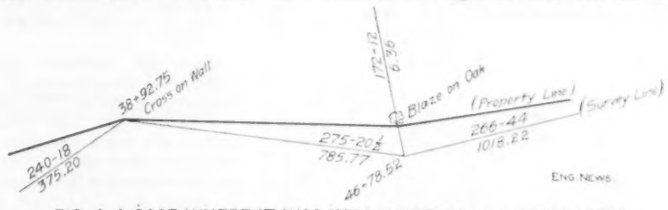

FIG. 4. A CASE WHERE IT WAS IMPOSSIBLE TO INCORPORATE A PROPERTY CORNER IN THE TRAVERSE.

This immediately suggests a very tempting method which certainly saves a great deal of time and labor in the field, but which has too many chances for error to make it desirable on first-class work; it is the method whereby the traverse does not run over the property corners, but near them, a side shot being taken to the corner and the bearing and length computed in the office. For the surveys in point this only had to be resorted to some half dozen times in a total of over 400 corners, and two side shots were never allowed to come in succession. The maximum length allowed was 10 ft.

It may not be amiss to note here another method of making property surveys which is all side shots. It is used on interior lines and where the land is comparatively cheap. A traverse measured with a steel tape is run so as to catch the corners, buildings, walls, etc., most conveniently, and each property corner is located by two stadia shots, one from each of two different traverse points. The property map will be on a scale of 1 in. = 100 ft. The traverse and shots are plotted on the map, the coordinates of the property corners scaled, and the bearing and length of the courses computed. On such work, the stadia interval up to 1,000 ft. is tested every few weeks and recorded in the note book, thus giving the correction to be applied when the notes are plotted. The practicability of this method has been fully established and it is very economical, 50 cts. per acre having been recorded in one instance for the field work.

To return, however, the traverse around the boundaries of the parcel was run first and then the points occupied again for the purpose of locating walls, fences, buildings, etc. Thus, an error in azimuth was discovered before 15 or 20 pp. of location notes had been taken.

System being the secret of speed and economy in any kind of work, the two operations were kept quite distinct, each having its own routine, as will be seen by the more extended description which follows.

The first operation was to go around the parcel, identify the lines and spot the angles, the old walls and fences in almost every instance being accepted as the line. Whenever the walls were cleared, they could be readily lined up by eye and the corner spotted very quickly, but where they were long and covered with trees and brush, the transit was set up to one side and offsets taken at regular intervals to locate the angles. Sometimes the walls were full of short crooks, in which case the offsets had to be plotted and an average line struck, a deviation of 2½ ft. to either side being allowed if the "give and take" was about equal. The corners were permanently marked by a cross cut on a solid stone whenever one was available; otherwise a chestnut hub was driven. The center of the road was frequently the line between two owners, and the roads were eminently of the country type, with no regularity at all either in width or alinement. A line was established midway between the walls, taking them as they were found, with no attempt at making the roads any uniform width, inasmuch as no description or layout could be found. To do this, stakes were lightly stuck into the ground half way between the walls at frequent intervals; these could be lined up by the eye, an average line determined, and the angle point readily located. In this way a great many short courses were avoided. This trip served also to familiarize the party with the general lay of the land—a by no means unimportant item.

Having the corners, the actual traverse was commenced, the party being distributed as follows: Two men went ahead putting in the additional traverse points required, giving foresights and doing the clearing when it was light. In heavy clearing, all hands turned in and pushed the line ahead, turning the azimuths but leaving the chaining to be done later. A rear flag, two chainmen, a transitman and an assistant engineer completed the party. This organization proved to be the most economical, nobody was waiting for anybody else, and all were moving steadily and continuously ahead. Each man had his own duties from start to finish, and was expected to be on the spot the minute he was wanted. The two chainmen followed the transit and did nothing but bring up the distance; the two men ahead kept themselves supplied with stakes, etc., picked out the best line for the traverse, and gave foresights. The assistant engineer kept the notes and filled in wherever there was a gap, employing his foresight in avoiding disturbances in the system.

Rulings on questions that are always arising were made at the start; thus much argument and shouting were avoided. For example, no course was to be less than 150 ft., unless the property line itself was short, in which case a long foresight was to be used to turn the azimuth from; plumb bob sights could be given only up to 300 ft., after that the steel lining rod must be used; the tape might occasionally be 2 ft. out of level in a full chain (100 ft.) in a difficult place; the chainmen had to get their own line, except when chaining down a steep slope, in which case the transitman gave them the points; the chainmen understood that on a long line on a wall or fence, where the chaining would be difficult, they could gradually diverge until they were some 3 ft. off the line, then keep parallel, swinging in again as they neared the other end; thus each man had the measure of the accuracy of his portion of the work, and knew the latitude allowed him.

Azimuths were carried along the traverse instead of turning angles at each set up, and they were set and read only once, checking them by the needle whenever there was no local attraction; they were read to the nearest half minute. True south was taken as zero azimuth, reading of course around through the west. Ordinary Buff or Berger transits were used.

The chaining was done with a K. & E. Excelsior tape graduated to hundredths. It was compared with the standard and no corrections for length or temperature were considered necessary. The chainmen had no difficulty in keeping the tape level and applying the proper pull, even though they were somewhat green at first. No attempt was made to make even 100-ft. measurements; a nail was pushed into the ground on line and measured to, each measurement being recorded on a page in the note book kept for that especial purpose and the pieces added together finally to get the total length of the course. As noted before, the chainmen followed the transit and got their own line, except when breaking chain down steep slopes. All sights were given with steel lining rods or plumb bobs.

The traverse having been finished, the azimuths closing within the allowable 2', the location of the walls and buildings was commenced, the stations being occupied a second time. This location was all done by the stadia method, and as the maximum length of shot was 600 ft. it was often necessary to run supplementary traverses to reach interior objects. On these, stadia distances were read both ways, no tack was put in the stake, and stadia rods were used to give the sights. The traverses were always closed out on some previous point and the error in azimuth never exceeded 4'. The traverses were not computed, the graphical check obtained when they were plotted on the map being quite sufficient. Here again the work was systemized, the same two men going ahead selecting the most advantageous points when interior traverses were required, two rods took all the shots, and the other two men measured buildings.

The work was carried on through the winter, but as there never was any great depth of snow and the temperature never became very severe, the rate of progress was not considerably reduced, the absence of leaves helping out by cutting down the amount of clearing quite materially. Full sized stakes were put in frozen ground by using a "frost pin." This was a piece of 1¼-in. steel 20 ins. long, pointed and flattened somewhat and driven down with a 6-lb. striking hammer. Hubs put in in this way were readily settled down after the frost was out of the ground, without disturbing the point appreciably.

THE NOTE BOOK.—The traverse notes were always put on a sketch which roughly approximated in shape and layout the parcel as it lay on the ground. Such a sketch is shown in Fig. 2, which, with the exception of the page on which the measurements of the courses were recorded, shows all the notes that were taken on the survey. The top of the page was always north. Here is seen at a glance the point where the traverse started, the azimuth used, the station, name of owner and page where it will be found, also the point which the traverse is tied up to, with a reference to its page, and, enclosed in a circle, the azimuth on the former survey, showing how the traverse closes for azimuth. A description of the station is noted as "cross on wall," "drill hole," etc., no note implying an ordinary hub. The stations are worked up in the field and marked on the witness stakes. The azimuth and distance always read the way the traverse was run. In the figure noted, the south and east lines were on previous surveys. The sketch could usually be made on one double page, but even if it ran over to the next page, no confusion was caused; the biggest parcel, 227 acres, only covered two double pages and was perfectly plain.

This method seems to have many advantages over the "straight line" method, in which the transit line always appears as a straight line, as in railroad work. The fact should never be lost sight of that the notes will be used a great

land which would be submerged is alkaline and of little value even for grazing purposes. The water could either be used for irrigating the lower lands in the lake bottom or allowed to evaporate. Reservoir sites of sufficient capacity to store all excess waters of the Tule are located on that stream. In the replenishing period of 1906, the waste water available for storage was 83,000 acre-ft. On the Kaweah River the water available during this period over and above the irrigation diversion of 2,000 sec.-ft. was 336,500 acre-ft. It is not known accurately what amount of storage can be developed, but small-scale contour maps indicate that nearly 300,000 acre-ft. is available by increasing the storage capacity of the numerous small lakes in the upper Kaweah Basin and utilizing two possible sites on the main river. On Kings River there is a total available storage capacity of about 300,000 acre-ft. in the Clarks Valley and Pine Flat reservoir sites. If the present irrigation diversion of 4,000 sec.-ft. be subtracted from the monthly mean flow of Kings River (Table II.), and half of the remainder obtained, it will be found that waters which at present would enter Tulare Lake would exceed the possible storage only in the years 1884, 1901 and 1906. In other words, if the possible storage is developed on Kern, Tule, Kaweah and Kings rivers there will be no necessity for disposing of flood waters except in years like 1884 and 1906, and then only on Kings River. This can be done in one of two ways, either by building a large storage reservoir in the center of the lake basin or else turning the flood water into the San Joaquin River. The latter can be easily and cheaply accomplished and would be the most feasible, unless complications should arise, caused by swelling the flood of the San Joaquin when the protecting levees on the lower river are already taxed to the utmost.

The cost of the above scheme for reclaiming the lake bed would be large, but it is believed that the area and earning capacity of the land reclaimed is amply sufficient to bear the expense. The principal crop which has been thus far raised on the land is wheat. The number of sacks per acre harvested in a normal year varies from 20 to 25. Under exceptionally favorable conditions 35 sacks have been harvested. The average weight of a sack of Tulare Lake wheat is 143 lbs. The yield per acre is, therefore, from 2,800 to 3,600 lbs., with exceptional cases of 5,000 lbs. Adopting 20 sacks per acre as an average yield and assuming a market price of $1.25 per 100 lbs., the gross return per acre is $35.75. In 1906 the area planted was about 200 square miles. If this crop had matured its value would have been at least $4,600,000. In addition to the lake land there are large areas of productive foothill land which lie idle at the present time on account of insufficient water for their irrigation. The storage reservoirs, if constructed, would soon pay for themselves by supplying water to these foothill lands.

There is thus good reason to believe that the reclamation of the Tulare Lake Basin is feasible, both from an engineering and financial standpoint.

A PROPERTY SURVEY AND ITS COST.

By Arthur W. Tidd,* Assoc. M. Am. Soc. C. E.

The property surveys for the Croton Falls Reservoir, now being built by the New York Aqueduct Commission for the City of New York, were made during the season of 1905-6, and the method used by one of the parties on some 1,000 acres is described in this paper, together with its cost.

The method is not applicable to village surveys where the lots are small and of more value, but it gave very good results for the country covered.

DESCRIPTION OF PROPERTY.—The property consisted principally of farms and estates of very irregular shape and varying sizes, averaging 35 acres apiece, as will be seen by the table of owners and areas accompanying the cost data. The country was hilly, well cleared for the most part, and the river offered no obstruction to the work. The lines were usually well defined by old stone walls, fences, line trees, etc., readily identified and followed when once started, but some of the parcels were very indefinite and presented all kinds of difficulties. It so happened that these were also overgrown with woods and brush, and lay on steep side hills, precluding any possibility of long sights or rapid running of random lines. The deed descriptions dated back in many cases to the original patent, and were almost of no value whatever in determining the boundaries. Maps made at different times did not agree, and the owners themselves could not locate their lines within reasonable distances. In these parcels a great deal of time was lost running out old descriptions, trying to locate old landmarks and make things fit together. All the lines had to be cleared and re-run several times before a decision could be reached, for it was considered essential to actually place these indefinite lines on the ground when a decision was reached, rather than to calculate them on paper, since they were for the most part outside boundaries. One other odd feature which served to complicate matters was the presence of large deposits of magnetic iron ore, the existence of which the old surveyors were apparently unaware, and which of course played all manner of pranks with their bearings.

THE PROPERTY MAP.—The property map showed the property boundaries, field boundaries walls and fences, buildings, roads, railroads, rivers, brooks, springs and wells, flow line and flood line of the reservoir, telephone and telegraph lines, rights-of-ways, and water privileges. The bearings and distances around each parcel and the area were given, the bearings to the nearest minute, the distances to the nearest tenth, and the area to thousandths of an acre. The actual traverse line was shown in red, wherever it did not follow the property line; this, however, was not shown on the taking plans. Fig. 1 is traced from the map and shows all the information recorded thereon, except the number of the parcel, name of owner, and area in acres. Symbols were used to denote walls, fences, telephone lines, springs, etc.; in the figure, the dotted line is a wall, the full line the property line, and the dash and parallel marks a wire fence.

THE CONTROL.—The control of the basin was furnished by four so-called "base traverses" which were run along the roads, and in a general way encircled the reservoir. They were carefully run and served their purpose very well, although difficulty was experienced in making surveys that cut across between the Y-shaped upper portions of the basin, close out within the limiting error. The allowable error was 1 in 2,000 for the closure of the traverse, and 2' for the azimuth. These base traverses were all run and adjusted previous to the beginning of the property surveys.

THE SURVEY.—In making the survey, a traverse was run around the entire property, the traverse line and the property line coinciding wherever possible, as shown in the accompanying figures. The numbered points in the circles are the property corners, and are put on in the office, the stations are on the traverse and appear on the witness stakes that are left in the field. The stationing starts with 0 for each new traverse and ends only when the closure is made on some previously adjusted point. The property corners are crosses cut with a cold chisel on a permanent substantial stone in the wall whenever possible, otherwise a chestnut hub and a witness stake; the outside corners are to be marked by stone bounds eventually.

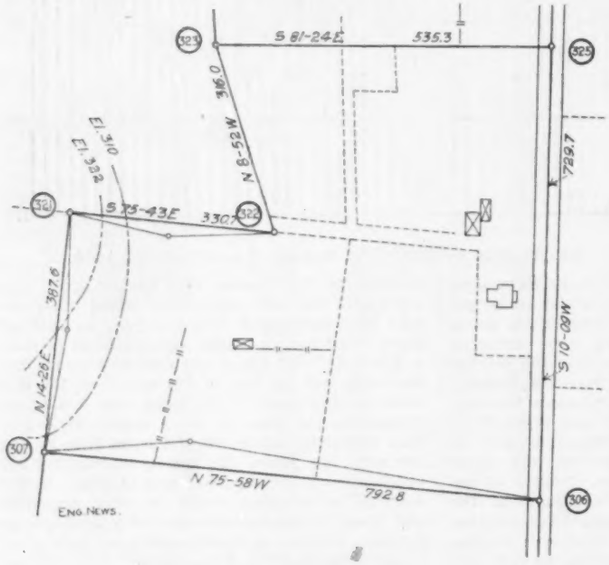

FIG. 1. A TRACING FROM THE PROPERTY MAP.

FIG. 2. A SKETCH OF THE SURVEY AS SHOWN ON A PAGE OF THE NOTE BOOK.

*Assistant Engineer, Board of Water Supply, New York City.

A study of the above shows that only five of the factors entering the second member are variables when a given tape is used. This means that the other factors in the terms may be combined in all work with that tape since they will not vary. In other words, we will have five constants for any steel tape expressed by the following equations:

$$X = \frac{L}{7.2\ E\ w\ P_o^2} \quad (1.)$$

$$X_1 = 7.2\ E\ w\ P_o^2\ a \quad (2.)$$

$$X_2 = 2\ P_o^2 \quad (3.)$$

$$X_3 = 0.3\ w^2\ E \quad (4.)$$

$$X_4 = L^2\ P_o^2 \quad (5.)$$

Substituting these values in the expression for the total correction above, it becomes,

$$C_t + C_p + C_s = n\,X\left\{X_1(T_m - T_o) + X_2(P - P_o) + \frac{X_3(P^2 d_s^2 - X_4)}{P^2}\right\}$$

From the above equation it will be seen that a table may be computed for a given tape which will suffice for obtaining easily the sum total for the three corrections. In this table the first column will consist of numbers arranged serially (1, 2, 3, 4, etc.), to represent the horizontal lines of the table. For the second, third, fourth, and fifth columns, compute respectively

$$\text{2d col.,}\quad A = n\,X$$

$$\text{3d col.,}\quad B = X_1(T_m - T_o)$$

$$\text{4th col.,}\quad C = X_2(P - P_o)$$

$$\text{5th col.,}\quad D = \frac{X_3(P^2 d_s^2 - X_4)}{P}$$

substituting, in A, successive values of n, as 1, 2, 3, 4, etc.; in B, the same successive values for $(T_m - T_o)$; in C, the same values for $(P - P_o)$; and in D, the same values for P. The arguments for entering the table will be the number of tape lengths; the difference between T_m and T_o; the difference between P and P_o; and P. Then, using the table, the summation of all corrections (exclusive of the slope correction) will be expressed by the formula

$$\Sigma\, C = A\,(B + C + D).$$

It must be remembered that the summation is algebraic, so that the sign is to be considered with the second and third arguments stated above; and that the numbers in the fourth column are negative. The numbers entered in the second column are the common logarithms of the variable nX since that form is the more convenient for the multiplication.

To illustrate practically: a steel tape with which certain work had to be done by the writer had the following values for the different constant factors entering into the first equations.

$L = 900$ ins. $\quad T_o = 62°$ F $\quad P_o = 10$ lbs.;
$a = 0.0000062 \quad w = 0.00068 \quad E = 28{,}200{,}000$ lbs./sq. in.

These values give the following constants:

$$\log X = \bar{5}.81415 \qquad \log X_1 = 1.93249$$

$$X_2 = 200 \qquad \log X_3 = \bar{3}.42490$$

and $$X_4 = 81{,}000{,}000.$$

An extract from the table would be

TABLE FOR CORRECTIONS FOR STEEL-TAPE MEASUREMENTS.

Correction for Temperature, Pull and Sag.

Formula: $C_t + C_p + C_s = A\,(B + C + D)$

[Arguments]	A $\log n\,X$ [n]	B $X_1(T_m - T_o)$ $[T_m - T_o]$	C $X_2(P - P_o)$ $[P - P_o]$	D $\frac{X_3(P^2 d_s^2 - X_4)}{P^2}$ [P]
1	$\bar{5}.81415$	85.612	200	− 214925.25
2	$\bar{4}.11515$	171.212	400	− 53328.64
3	$\bar{4}.29127$	256.812	600	− 23402.38
4	$\bar{4}.41618$	343.200	800	− 12928.15
..	.....	.....	....	.....
20	$\bar{3}.11515$	1712.120	4000	0.00
..	.....	.....	....	.....

n = Number of tape-lengths.

$T_m - T_o$ = Variation from standard temperature, in degrees Fahrenheit,

$P - P_o$ = Variation from standard pull, in pounds,

P = Pull in pounds.

The practical application of the table to any particular known or assumed conditions is evident, and the summation of the three corrections can be easily made.

In the above development it is assumed that the field measurements are made without intermediate supports. If intermediate supports are used, the constant X_4 changes, the factor L being replaced by the span between supports.

THE USE OF OIL FUEL FOR LOCOMOTIVES.*

The use of crude petroleum as a fuel for locomotives was first attempted in Russia, and the experiments were attended with such success that in this country the matter attracted the attention of some of the Eastern railways whose lines passed through the oil fields of Pennsylvania. However, the existence of a plentiful supply of a very superior grade of coal in the same region effectively blocked the further consideration of any change of fuel,† and the matter was not taken up again in America until the discovery of oil in the Southwest several years later. Up to this time the industrial problem of southern California had been the lack of cheap fuel, the entire supply coming from the coal fields of Australia and British Columbia, and this at a price so high as to prevent its use in manufactures, so that in 1893 and 1894, when the flow of oil started, the supply was far in excess of the demand. It was not long before methods were sought for adapting the new fuel to commercial purposes, and during the latter part of 1894 Mr. K. H. Wade, at that time General Manager of the Atchison, Topeka & Santa Fe Ry. properties in southern California, determined to experiment with oil as fuel for the locomotives. It was found that the heating value of a ton of crude oil was equivalent to that of 1½ to 2 tons of coal, and with coal at $8.60 per ton on tenders, against oil at about $5 per ton, the reduction promised in the fuel account was tremendous.

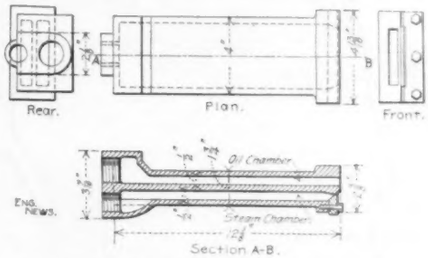

Fig. 1. The Booth Oil Burner for Locomotives.

The first burner used, which by the way was of the pattern now standard on the A., T. & S. F. Ry., was brought from Peru, where it had been successfully used by Mr. Booth, a former employee, in that country. It was patented in the United States under the name of the "Booth-Wade" burner. The first experiment was made on a Baldwin ten-wheel engine, having cylinders 19 x 26 ins. The diaphragm in the front end was removed and an ordinary petticoat pipe substituted; the grates were left in place and were covered with firebrick, leaving rectangular openings for the admission of air. The burner was fastened under the back water leg at the middle of the door sheet, and adjusted at such an angle as to direct the flame upward to a point under the arch about 9 ins. above the bottom of the front water leg. A brick arch was built in the fire-box, and the side sheets were protected by a wall of firebrick, built up to a considerable height, the idea being that the stay-bolts must be protected from contact with the flame. This primitive arrangement was found to be practicable, but the heavy exhaust of the engine when working with a load lifted the bricks bodily off the grates, and the next step was to remove the grates entirely, leaving the ash-pan in place, and placing above it a cast-iron false bottom. Both the bottom of the ash-pan and the false bottom were covered with firebrick. Rectangular openings were left for the admission of air for combustion, and the supply was regulated by dampers controlled from the cab.

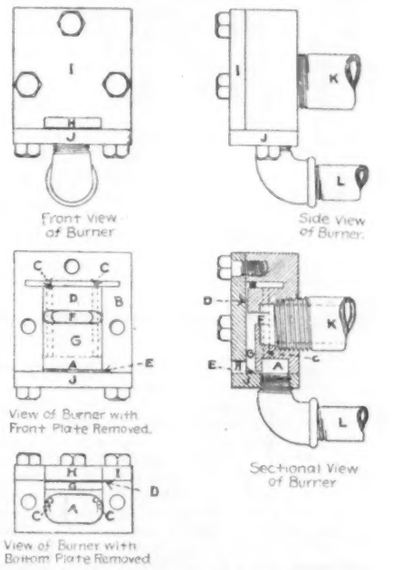
Front View of Burner
Side View of Burner.
View of Burner with Front Plate Removed.
Sectional View of Burner
View of Burner with Bottom Plate Removed

Fig. 3. The Hammel Oil Burner for Locomotives.

A. Lower Steam Chamber.
B. Upper Steam Chamber.
C. Parts Connecting Chambers A and B.
D. Top Atomizer from B to G.
E. Bottom Atomizer to Outlet.
F. Oil Inlet to Mixing Chamber G.
G. Mixing Chamber.
H. Outlet Orifice.
I. Front Plate.
J. Bottom Plate.
K. Oil Supply Pipe.
L. Steam Supply Pipe.

The burners now used are of two general types, classified as "outside" and "inside" mixers, according to whether the steam jet is brought into contact with the stream of oil before leaving the burner, or whether the two are brought together in the air. Of the latter type are the "Booth" (Fig. 1), now used exclusively on the Atchison, Topeka & Santa Fe Ry., and the "Best,"* which has been tried, but is better adapted for stationary work. Of the former type are the "Sheedy" (Fig. 2), which is standard on the Southern Pacific Ry., and the "Hammel" (Fig 3), on the San Pedro, Los Angeles & Salt Lake Ry. Each burner has its supporters, and seems to give satisfaction and high efficiency, so that the design of a burner does not seem to be of vital importance.

The usual arrangement adopted has been to place the burner in the back end of the firebox, using a brick arch, but in later years a design has appeared using the same burner placed in the front end of the fire-box, dis-

*Abstract of a committee report presented at the annual meeting of the Traveling Engineers' Association, at Chicago, in August. A paper on the use of oil fuel for the locomotives of the Tehuantepec Ry. (Mexico) was published in our issue of Aug. 9, 1906.

†The facts that the oil was of more value for commercial purposes and that the amount available for railway purposes would have sufficed for only a limited number of locomotives were other reasons why no extended use was made of the Pennsylvania oil. Particulars of the early use of oil for locomotives in Russia and Peru were published in our issue of Aug. 25, 1892.—Editor, Engineering News.

*The "Best" is used on the Tehuantepec Ry., as noted in our issue of Aug. 9.

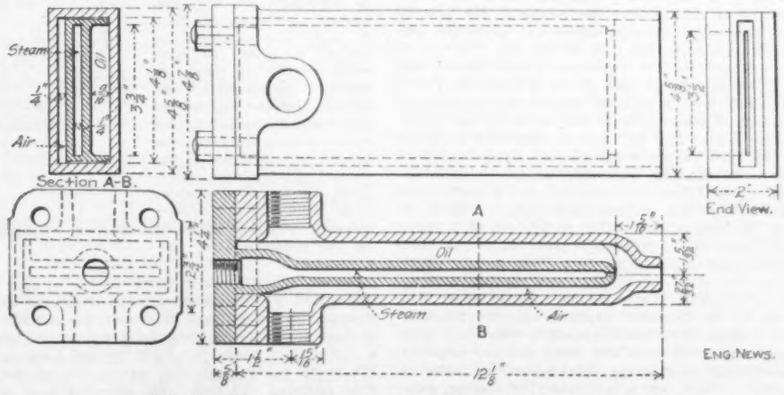

FIG. 2. THE SHEEDY OIL BURNER FOR LOCOMOTIVES.

deal more by somebody else than by the man who took them, and a person with a complete sketch before him can locate himself, find what he wants, interpret it quicker, more intelligently and with less chance of getting twisted than where page after page presents the same appearance.

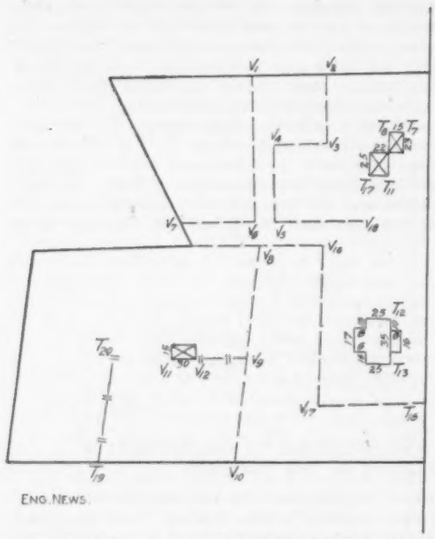

Fig. 5. A Page of the Note Book, Showing the Key to the Shots for Locating Walls, Buildings, Etc.

A second sketch is made showing the walls, road lines, buildings, etc., as in Fig. 5. This is the key to the stadia shots, Fig. 6, by which the man who plots the notes knows how to connect up his points. Each rodman has his own distinctive letter, his initial, when there are no duplicates, and his shots are numbered consecutively beginning with 1 on every new parcel. The sketch also gives the dimensions of the buildings, and notes any item of interest, such as a right-of-way. Fig. 6 shows a portion of a page of the stadia location notes. The station occupied is given first, followed by the azimuth set on and the azimuth checked on. The extreme left-hand column gives the rodman and the number of his shot; the azimuth and distance follow with the description. In case vertical lines occur that would affect the length 4 ft. or more, they are read and recorded after the distance. The ingenious arrangement of the descriptions in conjunction with ditto marks is worthy of note as a time saving service, which in no way causes confusion. In the sample shown the station 8 + 50 occupied was on the Chamberlain survey previously made.

COST DATA.—It was possible to keep a maximum and a minimum cost, so to speak, of field work, and these are both given in detail, although the average will perhaps be of the most value.

Under what is termed the maximum cost, the record shows what was obtained under adverse conditions and circumstances, giving low progress and high cost. The work was done in a disconnected manner, being strung along from July to November, owing to efforts to obtain information from deeds and owners. The parcels were smaller, the lines obscure and indefinite, and much time was lost hunting for old landmarks and corners, running out old deeds, etc. Then, too, all the lines had to be cleared and usually lay on steep side hills. A smaller party was used—1 assistant engineer and 5 men, and they worked 36 days.

Owner.	Acres.	Owner.	Acres.
C. M. I. M.	10.5	Smalley	16.6
Willis	0.4	C. M. I. M.	7.5
Hobbs	18.2	Howes	22.1
Sneden	3.3	Vores	9.0
Russell	3.3	Smith	0.2
C. M. I. M.	26.8	Merrick	25.9
Sneden	57.1		
			200.5

32 x $7.03 = $224.96
57 x 4.31 = 245.67
52 x 3.35 = 174.20
72 x 2.68 = 192.96

Cost, $837.79 (Team not included.)

$\frac{200.5}{36}$ = 5.6 acres per day.

$\frac{\$837.79}{200.5}$ = $4.17 cost per acre.

Under the minimum cost, the record shows what was done under favorable conditions of country and party. The parcels were large and well cleared, the lines readily identified, and although the work was done in the winter, there was little snow and no severe temperature. The party consisted of 1 assistant engineer, 2 levelers, 3 rodmen and 1 axeman, with salaries respectively of $2,200 per year, $1,350, $1,050 and $840. The hours were from 8 to 5, leaving the office at 8 and being back there at 5, the average time to drive out being 35 minutes. A team and driver at $5 per day were used for transportation all the time, but are not included in the cost. The "number of days" means the actual days spent in the field, counting Saturday as a full day, although the hours were 8 to 12; in this case 33 days for the total.

Owner.	Acres.	Owner.	Acres.
Cornue	94.1	Kelley	33.8
Stebbins	42.7	Howes	36.1
King	51.4	Everett	22.5
Howes	70.8	Williams	3.5
Brady	227.3	Van Scoy	85.8
Kelley	6.5	Chamberlain	70.4
Smith-Clift	28.0	School No. 9	0.7
Ostrander	3.4		
			777.0

33 x $7.03 = $231.99
56 x 4.31 = 241.36
80 x 3.35 = 268.00
28.5 x 2.68 = 76.38
3 x 5.27 = 15.81

Cost, $833.54 (Team not included.)

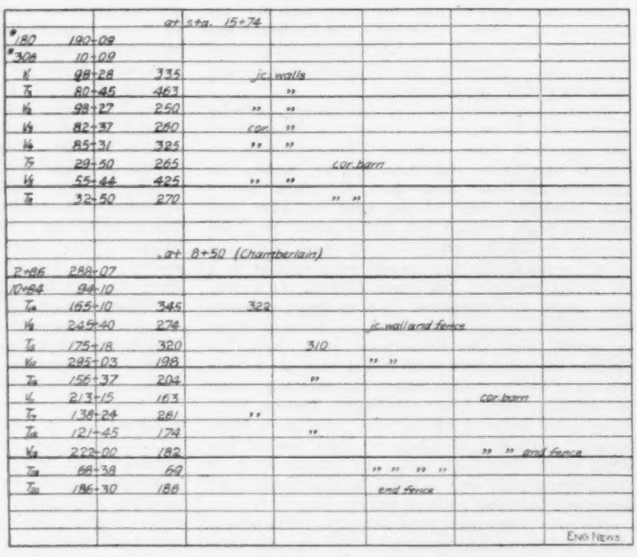

FIG. 6. PART OF A PAGE FROM THE STADIA LOCATION NOTES.

$\frac{777}{33}$ = 23.5 acres per day.

$\frac{\$833.54}{777}$ = $1.07 cost per acre.

The cost of the "base traverses" is not included in the above, as they were made by another party, but on some 7 miles of similar traverse run by the party that made the property surveys, and which consisted of 1 assistant engineer and 5 men, the progress was 8,000 ft. per day; any estimate, only a portion of this should be charged against property surveys, for the data were used for the stadia topography as well. Further is the cost of putting in stakes on the final line included, as this had been previously done, but a similarly organized party with two rodmen can cover 2 or 3 miles a day.

OFFICE WORK.—The office work was done by the field party at odd moments and rainy days, but in such a disconnected manner that no estimate of its cost could be kept.

CORRECTION CONSTANTS FOR STEEL TAPES.

By Hugh S. Brown.*

Where much work is done with a given tape or set of similar tapes, a combination of the formulas for correcting for temperature, sag and pull may prove useful, since certain constants can be deduced by means of which a correction table for the tape may be computed. By using such a table (an extract from a table the writer has used is given at the end of this article) the mathematical work of making the three corrections is much reduced.

The total correction for temperature is expressed by the following formula:

$$C_t = a\,(T_m - T_o)\,nL$$

in which

a = coefficient of expansion,

T_m = the mean of the various temperatures of the tape, Fahrenheit,

T_o = the temperature for which the tape was standardized, Fahrenheit,

n = the number of tape lengths,

and L = the length of the tape in inches.

The total correction for pull or stretch of metal, is

$$C_p = \frac{(P - P_o)\,n\,L}{E\,S}$$

in which

P = the tension or pull actually employed in the field work, in pounds,

P_o = the pull for which the tape was standardized, in pounds,

E = the modulus of elasticity of the metal (to be taken as 28,000,000 if not known),

and S = the area of cross-section of the tape, in square inches.

The total correction for sag is

$$C_s = \frac{n\,L\,w^2}{24\,P_o^2\,P^2}\,(P^2 d_o^2 - L^2 P_o^2)$$

in which

w = the weight in pounds of a linear inch of the tape,

d = the standard distance between supports for which the tape was standardized, in inches.

The above formulas have been taken indirectly from an authority on engineering.

Since 3.6 cu. ins. of steel weigh a pound,

$$S = 3.6\,w,$$

and in combining the formulas, the above value of S will be substituted for it.

The total correction, then, for temperature, sag, and pull, may be written

$$C_t + C_p + C_s = a\,(T_m - T)\,nL + \frac{n\,(P - P_o)\,L}{3.6\,w\,E} + \frac{n\,L\,w^2}{24\,P_o^2\,P^2}\,(P^2 d_o^2 - L^2 P_o^2).$$

Simplifying this equation, it becomes

$$C_t + C_p + C_s = \frac{3.6\,n\,L\,a\,E\,w\,P_o^2 P^2 (T_m - T_o)\,24 + 24\,n\,P^2 P_o^2 (P - P_o)\,L + n\,L\,w^2\,E\,(P^2 d_o^2 - L^2 P_o^2)\,3.6}{3.6\,w\,E\,24\,P_o^2\,P^2}$$

Separating this second member by taking the common factor

$$\frac{12\,n\,L}{3.6\,w\,E\,P_o^2\,24}$$

from each of the three terms and bracketing the remainder, the equation reduces to the following:

$$C_t + C_p + C_s = \frac{nL}{7.2\,E\,w\,P_o^2}\left\{7.2\,E\,w\,P_o^2\,(T_m - T_o)\,a + 2\,P_o^2\,(P - P_o) + \frac{0.3\,w^2\,E\,(P^2 d_o^2 - L^2 P_o^2)}{P^2}\right\}$$

*Lieutenant Artillery Corps, U. S. A., Fort Howard, Md.

pensing with the brick arch, and thus eliminating one of the heaviest expenses encountered in the use of oil fuel, namely, the maintenance of the arch. The initial cost of this brick work is about $25, and the life in some cases is as short as two or three weeks, and rarely exceeds three months. Checker work and flash walls have been tried as possible substitutes, and the indications are that the troublesome features will ultimately be done away with. Fig. 4 shows the present

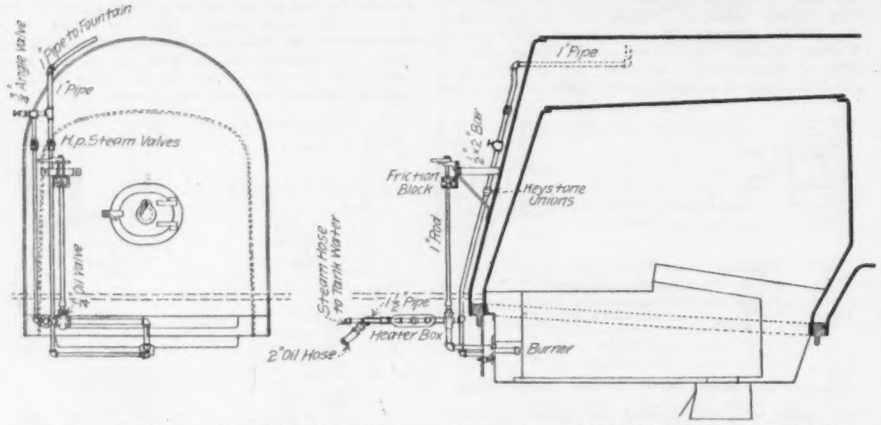

FIG. 4. FIREBOX ARRANGEMENT WITH OIL BURNER AT BACK; ATCHISON, TOPEKA & SANTA FE RY.

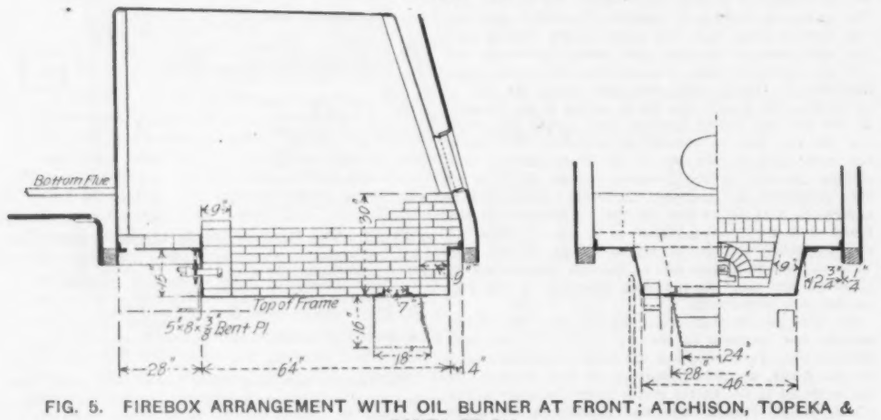

FIG. 5. FIREBOX ARRANGEMENT WITH OIL BURNER AT FRONT; ATCHISON, TOPEKA & SANTA FE RY.

standard arrangement for engines of large classes on the A., T. & S. F. Ry. System, with the burner placed in the back. Fig 5 shows the burner located in the front.

With the Hammel burner (Fig. 6), the brickwork arrangement is practically the same as that of the Sheedy burner used on the Southern Pacific Ry., shown in Fig. 6. Experiments with burners of various types and with different forms of ashpans and brickwork are constantly being made, and the final stage of perfection has not yet been reached. A new type of burner is now being tried on the A., T. & S. F. Ry. Coast Lines which bids fair to make considerable changes in the system of burning oil. This burner is known as the Lassoe & Lovekins burner (Fig. 7), and with it all brickwork is dispensed with, except that the bottom of ashpan is covered. The oil is taken from the tank by means of a pump and delivered to the burner under a pressure of 120 lbs. and the results so far both as to efficiency as a steam generator and as to the cost of maintenance have been very satisfactory.

The ordinary run of crude oil in this district will show in the calorimeter from 19,000 to 20,000 B. T. U., and repeated tests have been made giving an average evaporation of from 13 to 14 lbs. of water per lb. of oil, from and at 212° F., and an efficiency of about 80%. The best coal will not run more than 13,000 to 14,000 B. T. U., and with corresponding evaporation of from 10 to 12 lbs. of water per lb. of fuel. This explains one of the greatest advantages of oil as a fuel on locomotives—the ability to get out of a boiler with oil firing almost 25% more power than with coal. Oil-burning engines, as a rule, haul nearer their maximum tonnage at all times than coal-burning engines, and in passenger service make the schedule better, due not only to the increased steaming capacity, but also to their freedom from delays caused by poor coal, dirty fires, cleaning front ends, and other common ailments of coal-burning locomotives. The expense of fitting a locomotive to burn oil is not heavy, averaging from $500 to $700, the chief item being the tender oil tank, varying in capacity from 2,000 to 3,500 gallons.

The oil has a specific gravity of 13° to 20° Baume, or from 7.90 to 8.25 lbs. per gallon, and in cold weather it becomes necessary to heat the oil before it will flow freely to the burner. This is not necessary with the Texas oil, which is much lighter and thinner than the California product. The first engines were equipped with a small heater casting in the oil line just before reaching the burner, with a steam chamber adjacent to the passageway, thus effecting the necessary increase in temperature. As the engines became larger, and a correspondingly larger quantity of oil must flow to the burner, this device was found inadequate, and a coil of pipe was introduced into the tank, heating the oil with steam direct from the boiler and before it flowed from the tank. This method is now in general use, the piping being so arranged that when necessary steam can be admitted direct into the oil, and thereby raise the temperature in a much shorter time. Most of the oil in use has a certain proportion of water present and the use of the direct heater also has a tendency to precipitate an additional amount; provision is made to drain this off from the bottom of tank, as with water in the oil there are several objectionable features. The fire will be repeatedly extinguished by the water coming through the burner, and a series of explosions follow, with consequent damage to the brickwork, while the gas formed makes it very uncomfortable on the engine and in passenger cars.

The oil flame causes a heavy deposit of soot in the tubes, and this of course seriously interferes with the steaming of the engine. To remedy this trouble it was at first customary to open the fire-door and throw in a shovelful of sand, the finely divided particles being caught up by the draft and carried through the tubes, thus removing the soot. The powerful back draft of the flame when the door was opened made the sho objectionable, and at present a small circular open is left in the center of the fire-door, through which placed the sand scoop (Fig. 8), and with careful ha ling the sand is thoroughly scattered over the fire- and reaches all the tubes. When sand is being appli if the engine is being worked light, it is better to d the reverse lever down for a few moments and there increase the draft so that the sand will be carr through the tubes with the greatest velocity. A hea black smoke always follows the application of the sa and the operation should be repeated at frequent inte vals.

Another defect that is common when the heavy oil used is the formation of carbon immediately in fro of the burner which has an effect of deflecting th blaze upward and over the arch and always results i the steaming of the engine being impaired. All engin are equipped with a small bar for removing this forma tion and it only requires a few minutes work for th fireman. This defect has been remedied to a consider able extent by having a small opening in the botto of the pan directly under the burner which admits a sufficient current of air to deflect the oil from the botto of pan and prevent the carbon from forming so rapidly.

It is necessary in handling an oil-burning locomotive that the engineman and fireman act together to secure the proper results. Every change of the throttle or reverse lever must be immediately met with a change in the oil supply and adjustment of the atomizer, as a heavier or a milder draft means that more or less air will be drawn in for combustion, and for proper firing it is very essential to maintain the proper mixture of oil and air. With oil, as with coal, an insufficient air supply makes itself manifest by the black smoke at the stack and an intelligent fireman soon learns how much air is necessary to prevent it.

The steam gage quickly shows when the oil supply is too small, and the fireman's closest attention is demanded to see that the oil and air supply are adjusted to properly meet the variations in the work of the engine. Poor firing will invariably result in leaky flues. The fire must always be burning before the throttle is opened, or otherwise the effect of the sudden suction of cold air through the tubes will be disastrous. For the successful operation of an oil-burning engine the tubes and fire-box must be perfectly tight.

The advantages of the oil-burning system make themselves apparent in many ways, and possibly the greatest of the disadvantages fall entirely upon the mechanical department. The freedom from smoke and cinders can be appreciated by one accustomed to a coal-burning road. The transportation department is the gainer in having its engines ready for service in the quickest possible time after coming in from a run. One to two hours suffice as a rule for turning, there being no ashes to dump, no fires to clean or front ends to clear. The cost of handling the engines at terminals is at least 50% less than with the coal-burners, and by a convenient arrangement the engines can take fuel and water at the same time. The largest engines are no more difficult to fire than the smallest, and with summer temperatures of 125° to 135° F. in the shade on the western deserts the advantages to the fireman can be appreciated by those men who handle from 20 to 30 tons of coal in passing over a division. The claim department has not to pay for fires set by sparks from the locomotives, and there has not been a case of a bridge being set on fire since the oil-burning system has been installed, whereas when coal was used as fuel on the same divisions fires were very frequent. To pay for all these advantages, the mechanical department bears the brunt of the burden, in the increased cost of repairs.

The oil flame inflicts severe punishment on the tubes and fire-box, and it is exceptional when an engine will run two years without renewing the fire-box, or longer than 12 months with a set of tubes. It is almost useless

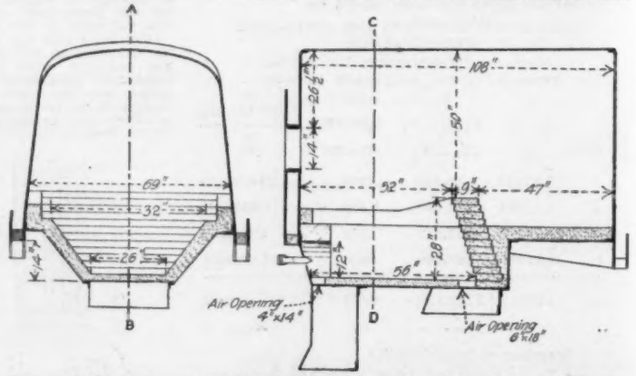

FIG. 6. FIREBOX ARRANGEMENT FOR OIL BURNING LOCOMOTIVES; SOUTHERN PACIFIC RY.

attempt to patch the side sheets, as the flame is so intense in its heat that the extra thickness of the metal prevents the heat being taken up by the water and the patch is soon burned. The side sheets crack more frequently immediately back of the arch, evidently due to the heat being more intense at that part of the fire box.

Attempts have been made to use oil fuel with the Vanderbilt type of fire-box, but with very poor success, the intense heat causing it to bulge and sag.

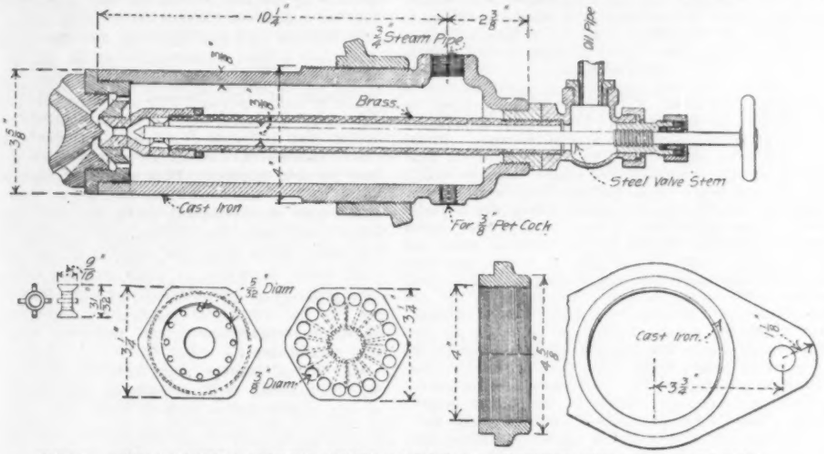

FIG. 7. THE LASSOE-LOVEKIN DOUBLE-HEAD OIL BURNER FOR LOCOMOTIVES.

In some instances it was necessary to renew the fire-box after three months' service.

The Atchison, Topeka & Santa Fe Ry. has one engine built specially for oil burning and it has given good success, the only objection being that it is necessary to hold it out of service for a much longer time than the engines with the standard firebox due to the difficulty in getting at the tubes in case any work is needed. This engine has three corrugated fire-boxes 28 ins. in diameter leading into a combustion chamber 40 ins. long, and from this chamber the tubes lead to the front end. In case of tubes leaking it becomes necessary to remove all the brickwork out of one of the boxes and let the engine cool for about 12 hours before a man can get into the chamber. This engine has been in service for four years and the boxes have not yet shown any signs of deterioration. It is objected to very seriously by the crews on account of the noise in the cab, as all the burners are in the cab and not under the deck as in other engines. Efforts have been made to deaden the sound by placing a shield made of two thicknesses of sheet iron with 1 in. of asbestos between the sheets. This has somewhat improved the conditions, but there is yet much more noise than on the ordinary engines.

With the ordinary fire-boxes, radial stays have replaced button-head crown-bolts, with less likelihood of burning off the heads and dropping crown-sheets, and with a better circulation above the crown-sheet. Seams are dispensed with wherever possible, both side-sheets and crown-sheets being usually made in one wrapper sheet, and an experiment has been lately made, and attended with success, of reversing the flanges on door and flue-sheet so as to bring the riveted seams into the water space, away from the flame.

The Southern Pacific Ry. has 900 locomotives equipped for burning oil. The Atchison, Topeka & Santa Fe Ry.

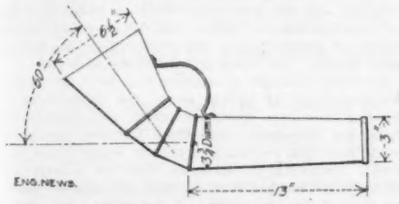

Fig. 8. Shoot for Sand to Clean Tubes While Locomotive is Running.

has 315 on its Pacific Coast lines and about 200 on its Texas lines. The San Pedro, Los Angeles & Salt Lake Ry. has 75, and smaller lines in California are using oil exclusively. It is a conservative estimate that at least 1,800 oil-burning locomotives are now in use in the United States.

A NEW MUNICIPAL ELECTRIC GENERATING STATION is now nearing completion at Johannesburg, Africa. It is to operate the tramways and furnish light and power over an area of 100 sq. mi. Producer gas is to be used and two gas engines of 1,000 HP. and 2,000 HP., respectively, have been installed.

ARE HIGH STEAM PRESSURES FOR LOCOMOTIVES ADVANTAGEOUS?

The subject of the relative values of high and low steam pressures in locomotive boilers has been under investigation at the mechanical engineering laboratory at Purdue University, and the conclusions of the report made by Prof. W. F. M. Goss upon these tests were given in our issue of Nov. 22. We have since received a copy of the extended discussion which followed the presentation of this report at a meeting of the Western Railway Club, and our abstract of the more important portions of this, together with the closing remarks of Prof. Goss in reply, are given below. We have also referred to this discussion in our editorial columns.

In opening the discussion, Mr. F. H. Clark, General Superintendent of Motive Power of the Chicago, Burlington & Quincy Ry. System, considered that a study of the report should enable the advisability of continuing to use high pressures to be determined. With such pressures there may be a little gain in fuel economy, which is perhaps more than offset by losses due to leakage through packings, etc. It may also give the advantage of high power with a boiler of moderate size, as compared with somewhat less power from a boiler of the same size using lower pressure, or equal power from a larger boiler also using the lower pressure. In many cases the boilers have reached weights which cannot well be exceeded, and it would seem that superintendents of motive power have been inclined to build boilers for higher pressures without fully realizing the disadvantages of such pressures. Mr. J. F. De Voy, Mechanical Engineer of the Chicago, Milwaukee & St. Paul Ry., agreed with the report and was convinced of the desirability of lower pressures, but in view of operating conditions he did not think he could recommend the reduction of pressure on existing engines. Nearly 75% of the railways, especially in the West, have adopted pressures of 210 to 225 lbs., and his road is building at its shops a fast passenger engine with boiler designed for the latter pressure. He doubted if any balanced compound locomotives carry less than 210 lbs. As far as losses by leakage are concerned, he stated that it is a positive fact that there are piston-rod packings which will be steam tight and give as good wear with 200 lbs. pressure as with 180 lbs., and will last for two years.

Mr. Goodwin stated that on the Chicago, Rock Island & Pacific Ry., the policy for some time has been to cut down the boiler pressure, and it is believed that very good results have been obtained by this action. About two years ago an order was issued to reduce the boiler pressure by 10 lbs. on all engines carrying 200 lbs. or more. That gives the great majority of the engines 190 lbs., but all new passenger and freight engines purchased within the past two years have been built to carry only 185 lbs. The Pacific (4-6-2) type of engines for the heaviest passenger trains are an exception; these carry 200 lbs. Mr. M. J. McCarthy stated that the Lake Shore & Michigan Southern Ry. has some six or eight engines running between Toledo and Chicago that were designed to carry 200 lbs. This was reduced to 185 lbs., and at the same time the cylinder diameter was increased from 20½ to 21½ ins. But the road foremen do not approve of this, for the reason that when an engine carrying normally 185 lbs. loses 10 or 15 lbs. when not steaming well, the loss is more serious than it would be with higher normal pressure. The lower pressures have been in use only a few months, so that there has not been any noticeable difference in the maintenance of the boilers.

MR. HARRINGTON EMERSON (Consulting Engineer for the Atchison, Topeka & Santa Fe Ry.).—A few years ago we were told that high steam pressure in locomotive boilers was an ultimate to be striven for, the reasons being that the higher the pressure the less the weight of engine, the less the water used, and the greater the coal economy. We were next led into compounds, on the plea that there would be less cylinder condensation and greater expansion, and therefore also less water and less coal used. An era is now beginning of superheated steam, and the same old prizes are held up: less weight, less water, less fuel. Professor Goss convincingly shows that as to higher pressures there is nothing in it, that the practical economic limit is between 160 and 180 lbs. I wish that instead of limiting himself to simple engines he had at least indicated his opinion of compounds and of superheat. Will he come to us five years hence and tell us that there is nothing of practical value either in compounding or in superheating.

As a practical man, whose duty it is to make savings that show in the president's annual report, I wish emphatically to state that I no longer take any interest in advanced thermodynamic theories of which the reward is a theoretical fuel economy of 5% to 10%. Recently I went into such a theory myself. I figured out the furnace conditions under which oil would, in burning, transmit most of its heat units to the water, and after rigging up an engine we ran a test. The actual average consumption of oil on the division per 1,000 ton-miles was, during the month of the test, 89 lbs., but our experimental engine showed up with 126 lbs. There was not the least thing the matter with the theory, but leaky injectors, leaky firebox and flues, ill-fitting valves, etc., got away with the steam so that it did not show up in ton-miles.

This and a few other experiences led to a somewhat careful investigation of the fuel problem, and I found that for every pound of fuel actually used to move ton-miles, two pounds are lost between the mine and the furnace door. Repeated tests show that 70 lbs. to 80 lbs. is required to move 1,000 gross ton-miles over a virtually level road, yet repeated tabulations show that freight engines are charged more nearly with 230 lbs. for this same service.

Between the limits of 180 and 200 lbs. steam pressure Prof. Goss shows a fuel economy of about 5%, or, on my basis of ton-miles, an economy of 3.6 lbs. per 1,000 ton-miles. How can I give a passing thought to this 3.6 lbs., when I am trying to find out what becomes of the 130 lbs., or two-thirds of the total fuel, for which I find no equivalent in 1,000 ton-miles?

As to the pressures and repair costs of our different classes of engines, our road unit costs in the fiscal year 1904-5 were for the whole system $106.90; for the fiscal year 1905-6 they have been reduced to $78.61. The highest division (in California) was equipped with simple engines of low pressure and they showed a road unit cost of $159.20. The divisions of least cost on our system are Illinois and Missouri, where the costs per road unit are now down to about $70 and where of 150 engines 39 are simple with pressures of 150 to 180 lbs. and 111 are compounds with pressures of 220 to 225 lbs. From this it appears that our engines with 220-lb. pressure are costing less than half per road unit what the simple low pressure engine costs.

There is, however, no warrant for the conclusion that the high cost of maintenance of the California engines is due to their low steam pressures and to their being simple, nor that the low cost of the engines on the divisions east of Missouri is due to the fact that they are compound and use steam at high pressure. Repair costs were high in California owing to wages, oil burning, branch lines, hills, etc., etc.; and costs were low on the eastern division because wages were lower, material cheaper, branch lines few, grades few, shops and roundhouses at that time under more economical administration.

Our compilations show to what a very remote extent boiler pressure affects repair cost. Our simple engines carrying 220 lbs. cost us less than any other engines, only $50.29. Our simple engines carrying 150 lbs. cost us from $94.96 to $101.37, or double as much. One simple engine carrying 180 lbs. cost $113.08. Our compound engines of all types, balanced, Vauclain, tandem,

passenger or freight, carrying 220 to 225 lbs., cost from $73.50 to $91.69, or less than any of the low pressure engines. These curious practical results, so much at variance with theory, show that the man counts for far more than the particular type of engine or the steam pressure.

In the order of their importance the following affect the cost of maintenance of an engine: Design, materials, roadbed, engineman and fireman, dispatching, roundhouse care, shop care, water, coal, steam pressure. Undoubtedly if all these were what they should be, road unit cost might not exceed $25 as against the $50 to $200 of actual practice. On the other hand they might be even higher than $200 unless the men in control so inspire their subordinates as to make each one get the best out of all that is under them, and the human element is more important than anything else.

MR. W. E. SYMONS.—The presentation of this subject by Prof. Goss prompts the suggestion that the conclusions reached may possibly (through an erroneous impression) cause some scientific and technical, also operative and practical men to go farther backward, or in the direction of reduced steam pressure, than they have formerly progressed, coming forward with increased steam pressure. As has been said, a few years ago we went from low steam pressures to the high, first to the high pressures of single expansion engines, and by gradual progress to the compound locomotive, which came into quite general use, and was highly endorsed by most of the prominent engineers and operating men, who had to do with the operating or building of locomotives, and the compound principle which gave such excellent results was predicated upon the highest steam pressures reached in locomotive operation.

The points brought out by Prof. Goss as to the losses or negative effects resulting from those increased pressures were largely, if not completely lost sight of, and in many instances were completely ignored in items of expense of maintenance of locomotive boilers. In many instances, I am inclined to think, engines operated under the high pressures reached at that time, and in use at the present time were, as the result of these endorsements, placed in service in certain localities and under certain conditions to which they were not adapted, and under which engines with lower steam pressures would have proved much more efficient and economical. Again the negative results from the increased increment of pressure largely results from the fact that other portions of the complete machine, particularly the machinery, did not receive proper attention in the way of providing for operating a steam engine with increased pressures. In other words, the entire locomotive was not improved in a general way to harmonize with increased steam pressures. This was particularly noticeable in such essential features as metallic packing for piston rods, valve stems, and other joints or connections, where it was essential to the successful operation of the engine that they should be kept perfectly tight. The same devices and methods were frequently employed with 215 and 225 lbs. steam pressure, that had been found satisfactory with steam pressures of 140 to 160 lbs.; the result was usually a failure and frequently the engine (as a whole) was condemned on account of unsatisfactory results that were directly chargeable to some particular detail which had not been given the attention it deserved.

I recall having taken service a few years ago with a system of railways having in its locomotive equipment about 250 engines, the maximum steam pressure carried on any of the engines (except about half a dozen recently purchased) was 160 lbs. It became necessary to add considerable power, and in the purchase of this power all the boilers were built under the very strictest specifications as to pressure, and carefully conducted tests were insisted upon at the locomotive works prior to acceptance, the limit being 200 lbs. The engines were placed in service with a reduced pressure of 20 lbs., or 180 lbs., and although some of them were assigned to a very bad water district where boiler repairs were the most important items, these engines under the conditions above described gave practically no trouble whatever. A record kept for some considerable period of time showed that the expense of maintenance was far below that of other engines, the boilers of which were carrying the maximum amount of steam for which they were constructed, and in making this comparison due allowance was made for the respective ages of the boilers.

I, therefore, think, that while the paper, as I have previously said, is not open to criticism, yet on account of the high standing of its author before the engineering and the railway world, I fear it may, through misconstruction, have some adverse effect on those who are now successfully operating locomotives with high steam pressure, both simple and compound. Whereas, in fact, it should have a most favorable effect, inviting a thorough analysis of all known complaints, defects, or adverse results in the use of high steam pressures.

MR. W. FORSYTH ("Railway Age").—I think we all agree with the conclusions of the paper, that there is very little to be gained by increased pressures, but the discussion shows that there is a reluctance to reduce the existing pressures as this would sacrifice the power obtained by high pressures. The suggestion that boilers be made larger in order to obtain greater capacity with medium pressures cannot have much effect upon the future locomotive design, for at present it is the practice to make the boiler as large as possible and fit it into the general design. The result of this is that a weight of 30,000 lbs. per driving wheel is imposed upon the rail, and it is doubtful if such loads can be successfully used in general practice, or can be exceeded without material injury to the track. The constant increase in the weight of locomotives is for the purpose of obtaining more power. The evident solution of this problem is the use of the water-tube boiler.

It may be interesting to give some figures relating to the weight and power of boilers of different types: In an eight-wheel locomotive (4-4-0) having 20 × 26-in. cylinders, 78-in. wheels and a total weight of 132,000 lbs., the boiler weighs 34,100 lbs., or 25.8% of the total weight of the locomotive. A simple Atlantic engine (4-4-2) with 20½ × 26-in. cylinders and 79-in. wheels, weighing 176,000 lbs. in working order, has a boiler which weighs 45,200 lbs. or 26%. In a decapod engine (2-10-0) weighing 260,000 lbs. in working order, the boiler weighs 86,313 lbs., or 33%. It is thus seen that the larger the engine, the greater percentage of its total weight is found in the boiler. The boiler in the Atlantic engine will develop a maximum of 1,500 cylinder-HP., so that the weight of the boiler is 30 lbs. per HP. The decapod engine will probably not develop over 1,600 HP., and the weight of this boiler is 41 lbs. per HP. For the actual application of the water-tube later to the locomotive we have an example in the Robert boiler*, which weighs 17,820 lbs., with a capacity of 800 HP., or 22.2 lbs. per HP. It would appear, therefore, that by the use of water-tube locomotive boilers it would be possible to reduce the weight per HP. from 50 to 60%, and practically no restriction would be placed on boiler pressure. The use of the superheater on locomotives shows that there is little difficulty in using steam in locomotive cylinders at a temperature of 600°, and the temperature of saturated steam at 500 lbs. pressure is far below this. If the principal objection to high pressures in the present type of boiler is due to bad water, it would certainly be more economical from an operating standpoint in most cases to purify the water than to reduce boiler pressure, and it would doubtless be found that when a good system of water purification is installed there will be no serious difficulties attending the use of a pressure of 200 or 220 lbs.

In regard to the quality of the water, Mr. W. Kelly remarked that high-pressure and bad water make a very bad combination, the effect of which is that firebox side sheets soon develop cracks which require continued attention by the boiler makers to keep the sheets tight. On some divisions of the Chicago & Northwestern Ry. where the water is not treated, the side sheets of engines using high pressure have to be renewed in from one to three years, whereas with engines carrying only 150 to 160 lbs. they last from five to 15 years. He has recently had two engines side by side in the shop, each requiring a new firebox; one of these carried 200 lbs. pressure and was only about two years old; the other carried 160 lbs. and was 19 years old. He was in favor of reducing the pressure provided the management could see the way to do this without trouble from reduction in power. Mr. H. T. Bentley, Assistant Superintendent of Motive Power and Machinery of the Chicago & Northwestern Ry., agreed with Mr. Kelly that high pressure and bad water make a bad combination, and pointed out that Prof. Goss had mentioned this particularly in his report. His road is using water treatment plants very extensively. In Iowa, when untreated water was used, engines required half side sheets and new tubes after about 30,000 to 40,000 miles run, but since the water has been treated and purified, the engines make runs of 150,000 to 200,000 miles before requiring renewal of the fireboxes, side sheets or tubes. Mr. R. D. Smith, Mechanical Expert of the Lake Shore & Michigan Southern Ry., pointed out that as the greatest trouble due to high pressure seems to be the leakage losses at piston rods, valve stems, relief valves, etc., it is possible that attention should be given to improving these parts rather than to reducing the pressure. According to the report the reduced pressure effects only a slight saving in coal consumption, and if more tonnage can be handled with this slight additional amount of coal the saving would be a poor argument in favor of the lower pressure. He did not b[elie]ve the pressure should be less than 200 lbs.

The lower pressures were spoken of favo[rably] by other speakers. Mr. B. H. Jeffries, of [the] Wabash Ry., said that some years ago, [in] competition among enginemen as to econo[mical] performance was very keen, an engine with [cy]linders 18 × 24 ins. and 180 lbs. pressure ra[n] as low as 8.2 lbs. of coal per car mile. No[w he] has an engine with cylinders 21 × 28 ins., we[igh]ing 197,000 lbs., and carrying 200 lbs. of st[eam], that has a coal consumption of 15 lbs. per [car] mile with heavy trains. Mr. P. H. Peck, Ma[ster] Mechanic of the Chicago & Western Indi[ana] Ry., remarked that one idea of the railway [in] using high pressure is to handle more cars [per] train and so save possibly one train crew to [every] four or five engines. This shows economical [re]sults in the train service, but while two train men may be dispensed with for five engines, about two more machinists and a boiler maker are required to keep the engines in service. So that what is saved in train service is lost in maintenance and repairs of engines. The sooner we find out what is the really economical point of boiler pressure the better, and Prof. Goss puts this at 180 lbs.

Mr. W. G. Wallace said that he had recently been connected with a railway having engines of the consolidation (2-8-0) type with cylinders 21 × 28 ins., some of which carried 160 lbs. and others 180 lbs. pressure. The average load of these engines on a 2% grade was 460 tons, but the engines carrying the higher pressure did not show any decided advantages over the others. Mr. Ira C. Hubbell suggested that an increase in power development of a boiler of given size might be accomplished by a more correct utilization of the steam in the cylinders, thus reducing the weight of boiler per HP. developed by the engine.

The remarks made by Prof. Goss in closing the discussion are given below, practically in full:

PROF. W. F. M. GOSS (Purdue University).—In response to the question that has been raised, let me say that it is not proposed to make heavier boilers for the sake of getting them larger. That would make locomotives heavier. It is proposed only as a first step to save weight by reducing the thickness of the sheets, and by lightening the staying and riveting. The weight thus saved will, in a slight degree only, be counterbalanced by an increase in the weight of the cylinders and of the pistons. My full report will show the relation of these weights for different pressures. I need only say now that the net saving in weight which results from a reduction of pressure is material. Having thus lightened the boiler by designing for a lower pressure, the next step is to restore it to its original weight by increasing its size. That is, I merely propose to commute weight saved by reducing pressure into weight to be used in securing additional heating surface.

As to the cracked side sheets, the side sheets of both the locomotives at the laboratory were of steel and of the same thickness. I do not know whether they were of the same composition. The failure after 30,000 miles run would not, I suppose, have been regarded an absolute failure on the road. Incipient cracks appeared which led to trouble in keeping the boiler tight.

There is nothing in my paper which concerns existing engines, and one should go slowly in reducing pressure on existing engines unless the cylinders are enlarged, though I admit that it may occasionally be done with good results. The whole problem is one of design.

My paper presents no argument in favor of increasing weights either of boilers or of the locomotives as a whole. These are questions which are entirely apart from my discussion. My whole purpose has been to show how best to utilize whatever weight may be allowed. Assuming, for example, that the general design of a locomotive has been so fixed that 35,000 lbs. may be allowed for the weight of the boiler, and that the designer must choose the pressure before he proceeds with his work. With the limit of weight defined, if he chooses 210 lbs., the extent of heating surface must necessarily be less than if he chooses 180 lbs. The conclusion derived from my investigation is to the effect that for the development of a given power, the locomotive will be most economical when supplied with the larger boiler designed for the lower pressure. It is in this sense only that my paper argues in favor of larger boilers.

There is nothing in my paper which points to a reduction of power in locomotives. When the steam pressure has been fixed, the output of power depends upon cylinder proportions and upon the degree of efficiency which attends their use of the steam. It is assumed that as pressure is reduced, cylinder volumes will be increased.

*Engineering News, June 15, 1905.

With this understanding of the matter, my contention, based upon experimental data, is to the effect that for highest economy, the pressure upon a single-expansion locomotive should ordinarily not exceed 180 lbs., because under this pressure such a locomotive will develop a given power more economically than if designed for any other pressure. Stating the same fact in different terms, such a locomotive, because of its superior economy under a pressure of 180 lbs., may be made to develop more power than a single-expansion locomotive of the same weight, when designed for any other pressure.

Finally, in this connection, due emphasis should be given to the fact that the selection of 160 to 180 lbs. as the running pressure of a locomotive, is not to be regarded as a backward step. The problem is to increase the efficiency and power of locomotives, and if it is shown that a reduction of pressure is a means to such an end, real progress is to be achieved by reducing pressure.

The discussion has raised the question as to the steam pressures in compound service, and mention has been made of the good results which follow compound engines using high steam pressure. I assume that it is understood that my paper simply concerns the single expansion engine; that the problem of the compound has not been considered. I also call attention to the fact that as a matter of simple theory we all know that the compound engine can properly utilize a higher pressure than can a simple engine, so that we should expect that a compound engine will do well under higher steam pressures than are desirable for a simple engine.

Now there is a matter of history that it is fair for me to give. Ten years ago the American Railway Master Mechanics' Association had a committee on high steam pressures, a preliminary report having been rendered in 1898.* That report gave results derived from a locomotive limited in pressure to 140 lbs. But it outlined a procedure which was later followed in securing the data which underlie the conclusions of the present paper. The point I would emphasize is that the problem to which I now bring you the solution was outlined and the outline was published in 1898. At about this time also Purdue University supplied itself with a locomotive having a very strong boiler for high pressures, and it was expected at that time that in a year or two data of value would be available. But nine years have elapsed since the plan was perfected, and the apparatus necessary to its execution supplied, and it is only now that we have been able to speak with certainty. These results might have been available long ago if the Purdue laboratory had had money which could have been put into operating expenses. The absence of special aid has required all work at the plant to be secondary to the instruction of students, and research has proceeded slowly. It was only after the Carnegie Institution came forward two years ago with a grant of $5,000 that the work long ago planned could be brought to a satisfactory conclusion.

What is being done in connection with the single expansion locomotive ought to be repeated in all of its details, first, with reference to the superheating single expansion locomotive and afterwards with reference to the compound locomotive. I am hoping that some way will open by which the activities of the laboratory will be greatly increased, in order that we may not need to wait ten years more before results can be had which will be of service in fixing practices with reference to these two important subjects. About $10,000 or $12,000 would cover both these researches.

*Engineering News, June 23, 1898.

THE INSTALLATION OF CENTRIFUGAL PUMPS.

By Wm. O. Webber,* M. Am. Soc. M. E.

There seems to be a general lack of information as to the capabilities of centrifugal pumps and the proper manner of installing them. The ideal conditions under which centrifugal pumps should be installed are, large quantities of water raised to comparatively low elevations. This is just as true now as it was when centrifugal pumps were first invented.

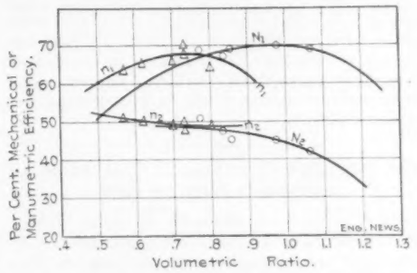

Fig. 1. Characteristic Curves of Two Rateau Multiple-Stage Pumps.

N_1 = curve plotted with mechanical efficiency values of 3.937-in., 5-stage pump.
n_1 = curve plotted with mechanical efficiency values of 3.149-in., 7-stage pump.
N_2 = curve plotted with manumetric values of 3.937-in., 5-stage pump.
n_2 = curve plotted with manumetric values of 3.149-in., 7-stage pump.

On the other hand, the introduction of multiple-stage pumps has done much to modify these conditions, and it is now practicable to lift water to much greater elevations with centrifugal pumps than was thought possible even ten years ago.

Isolated tests made on a specially prepared multiple-stage turbine pump produced efficiencies as high as 77%, and a series of tests made on Rateau pumps gave from 64.2% to 70%, as shown in Tables I. and II., and on the characteristic curves in Fig. 1. It is, however, safe to say that 65% represents the average commercial efficiency of the multiple-stage turbine pump in the market to-day, while 80% can be realized upon the straight, single impeller, volute, centrifugal pump at heads of less than 100 ft.

The best efficiencies of centrifugal pumps are supposed to have been obtained at discharge velocities equaling about 12 ft. per second through the discharge aperture of the pump. Recent experiments have shown that from pumps as large as 32 ins., 80% efficiency was obtained at 38.68 ft. lift, under a discharge velocity of 21.2 ft. per second, while some recent tests on very small pumps show gradually increasing efficiencies under heads up to 89 ft. and discharge velocities of 40 ft. per second.

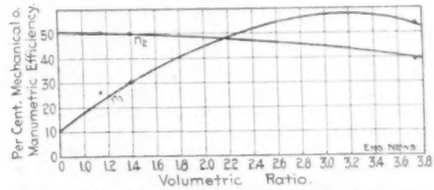

Fig. 2. Characteristic Curves of a 1-In. Lawrence Double-Suction Pump.

n_1 = curve plotted with mechanical efficiency values.
n_2 = curve plotted with manumetric efficiency values.

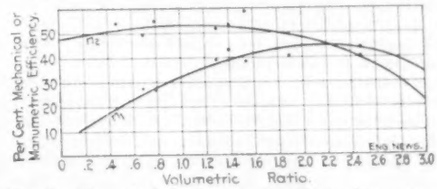

Fig. 3. Characteristic Curves of a 1½-In. Lawrence Double-Suction Pump.

n_1 = curve plotted with mechanical efficiency values.
n_2 = curve plotted with manumetric efficiency values.

It is, however, impossible to realize the same efficiency in small pumps that is obtainable in larger pumps. The statement which the writer made in 1886,* "that a 2-in. pump giving an efficiency of 38%, a 3-in. pump giving 45%, and a 4-in. pump giving 52% efficiency, were giving as good results proportionately as a 5-in. pump at 60% or a 6-in. pump at 64% efficiency," is fully borne out by recent practice, but might be extended by saying that the results stated are proportionately as good as 77% on an 18-in. pump, or 80% on a 32-in. pump.

The complete records of the Mississippi River Commission tests on the government dredges show that there is only about 4% difference in favor of the enclosed, or shrouded, impeller over the open impeller.

The tests of 1-in. and 1½-in. pumps given in Tables III. and IV., respectively, show that it is not a good commercial proposition to attempt to pump much less than 100 gals. of water per minute with a centrifugal pump. A single impeller pump should not be used to elevate water over 150 ft.

The double-suction pump is believed to be superior to the side-suction pump, although tests of side-suction pumps, when new, have given higher efficiencies than double-suction pumps of the same size and general design. Side-suction pumps, however, soon wear loose, and deteriorate in efficiency, while the double-suction pump, with the open impeller, does not deteriorate for a long time; the open impeller pump should therefore be preferred to the inclosed impeller pump, for general service.

A centrifugal pump cannot work as efficiently when pumping through a series of elbows and

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TABLE I.—Tests of a 3,937-In., 5-Stage Rateau Pump. Impeller Diam. = 10.6 Ins.

R.P.M.	H + h	Cu. Ft. Sc.	W. HP.	E. HP.	n_1	C_1	$\frac{C_1}{\sqrt{2gh}}$	V_4	n_2	n_3	n_4
1,204	229	0.907	23.8	35.77	66.7	55.75	1.026	10.55	46.8	8.3	57.6
1,425	340	0.990	38.35	56.15	68.5	66.	0.998	11.53	50.5	7.7	59.2
1,365	282	1.055	33.8	49.00	68.9	63.2	1.05	12.28	45.2	8.5	59.6
1,280	246	1.125	31.42	45.15	70.0	59.25	1.053	13.00	44.9	9.7	61.0
1,234	214.5	1.200	29.1	42.63	68.6	57.15	1.089	13.96	42.1	10.6	59.6

TABLE II.—3.149-In., 7-Stage Rateau Pump. Impeller Diam. =10.6 Ins.

R.P.M.	H + h	Cu. Ft. Sc.	W. HP.	E. HP.	n_1	C_1	$\frac{C_1}{\sqrt{2gh}}$	V_4	n_2	n_3	n_4
1,200	340	0.62	24.00	37.60	64.2	55.65	0.997	11.48	51.0	5.7	54.4
1,194	330	0.67	25.02	38.60	65.1	55.35	1.004	12.4	50.2	6.2	55.4
1,140	308	0.73	25.61	38.86	65.6	52.85	0.993	13.5	49.1	7.0	55.7
1,180	318	0.775	28.00	40.31	69.4	54.70	1.01	14.35	48.7	7.3	58.2
1,166	315	0.795	28.55	42.10	67.7	54.05	1.005	14.7	49.4	7.3	58.0
1,150	299	0.836	28.35	44.20	64.2	53.35	1.016	15.5	47.6	8.0	55.1

TABLE III.—Tests of a 1-In., Double-Suction, Open Impeller Pump. Impeller Diam. = 7.9 Ins.; $\phi = 65°$; $r_1 = 0.328$ ft.

R. P. M.	H + h	G.P.M.	Cu. Ft. Sc.	W. HP.	E. HP.	B. HP.	n_1	V_4	C_1	$\frac{C_1}{\sqrt{2gh}}$	n_2	n_3
1,505	44.73	0	0	0	2.29	1.715	....	0	53.50	0.995	.....	....
1,550	44.73	27.7	.0617	0.3135	2.58	1.935	16.2	11.3	53.35	0.993	1.075	50.4
1,580	46.03	80.1	.067	0.352	1.71	1.368	25.7	12.25	54.35	0.998	1.145	50.2
1,470	43.33	91.2	.2032	1.002	3.42	2.56	39.1	37.20	50.60	0.958	3.74	54.7

TABLE IV.—1½-In., Double-Suction, Open Impeller Pump. Impeller Diam. = 13 Ins.; $\phi = 35°$; $r_1 = 0.5415$ ft.

R. P. M.	H + h	G.P.M.	Cu. Ft. Sc.	W. HP.	E. HP.	B. HP.	n_1	V_4	C_1	$\frac{C_1}{\sqrt{2gh}}$	n_2	n_3
1,340	96.24	47.3	.1053	1.155	8.26	5.79	19.95	8.55	76.00	.967	4.73	53.5
1,360	91.60	70.1	.1561	1.63	8.95	6.25	27.1	12.59	77.1	1.002	6.9	49.4
1,300	91.62	77.4	.1726	1.8	9.52	6.66	27.0	14.00	73.7	.961	7.98	54.3
1,360	87.00	126.	.2807	2.78	10.2	7.15	38.9	22.75	73.7	.985	12.98	51.5
1,300	89.31	136.	.3023	3.065	10.86	7.13	43.0	24.58	73.7	.9725	13.98	52.8
1,220	87.00	141.	.3136	3.1	11.52	8.07	38.2	25.41	69.1	.924	15.41	58.5
1,220	73.15	172.5	.3842	3.195	11.80	7.92	40.3	31.2	69.1	1.006	18.95	49.2
1,240	61.60	229.	.5120	3.58	11.8	8.25	43.4	41.6	70.25	1.115	24.81	40.0

R. P. M. = revolutions per minute.
H + h = dynamic height.
Cu. Ft. Sc. = cubic feet a second.
W. HP. = water horse-power.
E. HP. = electric horse-power.
n_1 = mechanical efficiency.
n_2 = manumetric efficiency.
n_3 = volumetric efficiency.
n_4 = combined efficiency.
C_1 = velocity of impeller periphery in feet per second.
$\frac{C_1}{\sqrt{2gh}}$ = ratio of impeller velocity to velocity due to gravity.
V_4 = velocity through discharge aperture of pump in feet per second.
G. P. M. = gallons per minute.
B. HP. = brake horse-power.
ϕ = discharge angle.
r_1 = radius of the outer end of the propeller blades in inches.

*Engineering News, June 23, 1898.

*"Transactions of American Society of Mechanical Engineers," Vol. 7, p. 609.

bends as through a perfectly straight, unobstructed pipe. Experiments have shown that the obstruction caused by valves and fittings are approximately as given in Table V.

TABLE V.—Obstructions Caused by Valves and Fittings.

Name of fitting.	Number of feet of clean, straight pipe of same size which would cause the same loss as the fitting.
6-in. Pratt & Cady check valve....	50
6-in. Walworth globe check valve..	200
4-in. Pratt & Cady check valve....	25
4-in. Walworth globe check valve..	130
2½-in. to 8-in. long-turn ells.....	4
2½-in. to 8-in. short-turn ells.....	9
3-in. to 8-in. long-turn tees.....	9
3-in. to 8-in. short-turn tees.....	17
⅛th bend	5

Other experiments have shown that there is a loss of efficiency of 1.2%, and a loss in velocity acquired of 9% in a restricted aperture, over an absolutely unobstructed discharge delivery of a centrifugal pump.

Water entering centrifugal pumps should never have a velocity exceeding 8 ft. per second. The approach to the pump should never be abrupt, but gradual and with uniform changes, so that a centrifugal pump should always be installed with taper connections on both suction and discharge. The practice of placing a valve, or elbow, directly upon the discharge of a centrifugal pump is one to be most strongly condemned.

The United States Drainage Commission tests have shown that the best circumferential velocity for the impellers of centrifugal pumps is approximately 50 ft. per second. This would represent, for example, a whirl velocity through the discharge of the impellers of, say, from 30 to 40 ft. a second, which velocity must be slowed down to 12 ft. per second or less in the discharge piping connected with the pump.

An elongated cone of rapidly moving water is produced in the interior of the pipe, with slower eddies of water along the interior periphery of the pipe. Bends should not be introduced in that part of the pipe where the water has not reached a normal velocity. With pipe of the same size as the discharge aperture of the pump, this will not be effectuated in less than 30 diameters of the pipe. A taper connection and an increase of 30% in the size of the pipe would shorten the cone of rapidly moving water to probably a distance of 4 or 5 diameters. Tests seem to show that, for similar reasons, suction lifts of from 10 or 15 ft., with enlarged pipe and taper connections, will give better efficiencies than where pumps are submerged.

If possible, pumps should always be located directly over the water supply, so as to avoid long horizontal suction pipes. It is also much better to discharge vertically from a centrifugal pump, if it can be done without increasing the discharge head, rather than to discharge horizontally, so that the water will have a tendency to run away from the pump.

Probably the principal cause of dissatisfaction with centrifugal pumps is that the customer does not give the builder any information, excepting the number of gallons of water required to be elevated a certain height. It is imperative that the builder of a centrifugal pump should know the height from the level of water supply to the center of pump, from the center of pump to the discharge level, the length and size of discharge pipes, and the number of elbows and valves used in both suction and discharge pipes. If a centrifugal pump receives water under pressure, it should always be stated. The source of power to operate the pump should also be definitely recorded. If electricity, the type and voltage; if by belts, the available speed; if steam, the available pressure, superheat and vacuum.

Another important item is that of foot-valves. Apparently, none of the standard manufacturers of pipe fittings make a foot-valve that is fit to use with centrifugal pumps. In most of them, when the valve lifts far enough from its seat to give an area equal to the pipe, the valve itself lifts so far into the casing as to obstruct its own discharge area, and few of these valves have sufficient inlet passages in the strainer to properly admit the water. Foot-valves on centrifugal pumps should be of a kind in which the valve itself opens by swinging back entirely out of the line of current, and the area through strainers should be from two to three times that of the area of the pipe.

Never use globe valves on centrifugal pump piping, but always straightway gate and check valves. Do not use check valves in the discharge on long vertical columns, but gate valves instead. Remember particularly that the suction piping on centrifugal pumps must be air-tight as well as water-tight.

THE EXECUTION OF CONTRACT WORK FROM AN ENGINEER'S POINT OF VIEW.

By John S. Ely,* Assoc. M. Am. Soc. C. E.

In these days much is being published concerning improved methods of carrying on large construction work, accurate systems of cost-keeping, card index records, and similar subjects, showing that there has been of late years a considerable awakening in what might be called the contractors' department of engineering, and that there exists an increasing tendency to depart from old-fashioned rule of thumb and hit or miss methods.

Nevertheless, it would seem that development in this line is slow and behind the general advance in other lines of engineering progress. It may be because contractors as a rule are not engineers and lack scientifically trained minds, or it may be that the engineer himself is somewhat to blame. Whatever the reason, it is a fact that very many contractors still cling to the methods of twenty or thirty years ago. Their attitude regarding all improved methods is very much like that of some Western farmers toward the Agricultural Department of the Government, who shake their heads dubiously at "new-fangled notions" and prefer to raise forty bushels to the acre by their forefathers' methods rather than try new ways, notwithstanding the latter promise a yield of eighty.

One direction in which it would appear, from an engineer's point of view, that there is large room for improvement is in the matter of a definite and precise plan or program for carrying on a piece of construction work, such a program being usually conspicuous by its absence. The designing engineer makes elaborate plans for such a piece of work; each detail is figured out with mathematical precision; all probable conditions are considered and provided for, and the plans as a whole are as complete as science can make them. But usually how different are the contractor's plans for executing the work. To drive ahead and trust largely to Providence without more than a vague idea of the best order and sequence—in short without any well-defined plan—is probably as often the rule as not.

The foreman or superintendent in charge of contract work to-day is usually of the "practical" variety, a very useful and resourceful man, entirely familiar with the laborers and machines he has to handle—in other words, he is what is known as a good all-around foreman. It would not do to underestimate the usefulness of such men, to whom is due the successful execution of most large pieces of engineering work, and who could not be spared. At the same time it can hardly be denied that they are often uneducated men, neither accustomed nor able to work out the details of a complicated plan. Often they do not consider it worth while to look further than a few days ahead or to have any very definite program for their work. The future is a bridge to be crossed when reached.

As an example, on a certain large piece of construction with which the writer was connected there were to be constructed several groups of batteries of slow sand filters, the greater part of the excavated earth having afterward to be put on top of the finished filters. This excavation was made with steam shovels, the earth being hauled to a vacant portion of the ground for storage. A few months later, this ground being needed for some other purpose, the earth was again moved in the same way to another more distant place, and the process was actually repeated three times before the earth was in its final position. It has always appeared to the writer that by following a carefully worked out program the earth from the first battery would have been stored conveniently; that from the second battery would have been placed directly on the first when completed, and so on, handling part of the material twice and part only once. There may in this case have been other considerations of which the writer is not aware, but it will at least serve as an illustration.

But let us suppose that as a first step toward the execution of such a contract the contractor secures not only the services of the aforesaid superintendent, but also of an experienced engineer familiar with the costs and time required for the various kinds of work included in the contract, and that as a further step these men prepare in the greatest possible detail a program for carrying on the work, showing for each week, or even for each day, the work to be done on that day, the number of men to be employed, the amount of work which said men should accomplish, the materials and supplies which should be ordered, those which should arrive, and all similar information.

Having such a detailed plan on paper, and supposing, for the sake of argument, that it could be followed, the following would be some of its advantages:

(1) It would show the number of laborers of all kinds which could be used at each period of the work and how this labor could best be moved from one part of the work to another, thus avoiding the laying off and rehiring of men—a frequent cause of delay and dissatisfaction. Useful men are often laid off, and when needed later cannot be had.

(2) It would give a very close estimate of what the pay-roll would be at any period of the work.

(3) It would so arrange for the handling and storing of material, earth excavated, etc., that

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EXCAVATION.—BOILER HOUSE FOUNDATIONS—1604 CU. YDS. LOAM AND CLAY.

March, 1906 Item.	Amount.	Rate.	Total.	Per Cu. yd.
Foreman	420 hrs.	$0.30	$126.00	$0.079
Laborers	3,400 "	.15	510.00	.318
Carts	790 "	.30	237.00	.148
Carpenter—on shoring	8 "	.40	3.20	.011
Lumber— "	500' B. M.	.03	15.00	
Tools, repairs, etc	.....	.....	10.00	.006
Total	.....	.....	$901.20	$0.562

Note.—Laborers averaged 0.47 c. y. per hour. Cart-haul, 200 ft.

BRICKWORK ON————CHIMNEY—STONE BASE TO BRICK BELT.

June, 1906 Item.	Amount.	Rate.	Total.	Per M.	
Labor—Foreman	32 hrs.	$0.75	$ 24.00	$0.615	
Bricklayers	200 "	.60	120.00	3.077	
Laborers—handling material	230 "	.15	34.50	.885	
—building scaffold	20 "	.15	3.00	.077	
Carts	60 "	.30	18.00	.461	
Total for labor	.....	.....	$199.50	$5.115	
Material—Common brick	34 m.	$ 9.00	$306.00	$ 9.000	
Red pressed brick	5 m.	15.00	75.00	15.000	
Mortar—Sand	25 ton	.60	15.00	.385	2.590
Mortar—Lime	122 bu.	.25	30.50	.782	
Mortar—Cement	37 bbls.	1.50	55.50	1.423	
Total for material	.....	.....	$482.00	$12.359	
Total cost	.....	.....	$681.50	$17.474	

Note.—Bricklayers averaged 195 brick per hour = 5.1 hours per M.

ey would have to be moved the least number f times and the least distance. A very large em of expense in construction work is the hand- ng and rehandling of such material.

(4) It would indicate when and in what quan- ty to order material, so that it would be on and when needed. Delays are caused by such rders being forgotten or neglected.

(5) It would show when such material should rrive and what should be done with it.

(6) It would so divide up the time in which the ork was to be done according to contract that he contractor would know at all times whether e was ahead or behind time and when the work as likely to be actually finished.

(7) It would be of great help in showing whether the different foremen were or were not etting a due amount of work out of their men, nd whether the costs were running above or elow the estimated cost of the work.

But the objection to all this would probably be hat even if such a program were made it would e impossible to follow it; that unforeseen con- ingencies and delays are always bound to arise, nd so on.

It is not, indeed, to be supposed that such a plan could be followed without change; it would probably be frequently changed to advantage as the work progressed; but even so, could not a much better grasp be had on the work as a whole and much valuable time and money be saved? It would probably be more practical to divide the time into periods of ten working days, thus making due allowance for bad weather and unavoidable delays.

And even though it were not followed, it is surprising how in the mere making of such a detailed program the different parts of a work may be made to dovetail and fit into one another, and how many methods are seen by which expense may be avoided, but which would probably never be thought of otherwise; and also how the more carefully and minutely the plan is worked out the more such possibilities occur. Such being the case, is it not a mistake to condemn off-hand the making of a minute and elaborate program on the plea that unforeseen circumstances will render it useless?

Another matter which comparatively few contractors seem to consider worth much attention is the keeping of detailed records of the cost of the varying kinds of work on a contract; they usually depending entirely on the balance in the ledger as to whether they are making or losing, and having often only a vague idea of what particular items they are making or losing on.

Such details are not difficult to keep, and are of great value when carefully kept. They are invaluable when bidding on new work, and would be so in the making of such a program for work as has been outlined here.

On large contracts it would probably pay to employ one or more clerks whose sole duty it would be to keep such records, putting them all in convenient and accessible form. The ever-ready card index system suggests itself here as the most convenient method, and has been used for this purpose by the writer to keep such cost data as he has been able to gather. Two of these cards are shown herewith. If desired, different colored cards may be used to indicate different kinds of work, as excavation, concrete, and so on.

Clever foremen sometimes cheapen the cost of such work as trench excavation by laying off a certain portion for each laborer and paying him for a day's work when his portion is done. This method cannot be used on all kinds of work, but when possible it has the double advantage of less cost and of greater certainty as to just how much work will be done.

A contract was let not long ago for the placing of sand in six filter beds. The work was done by the time-honored combination of Italian and wheelbarrow, and cost the contractor 27 cts. per cu. yd., paying the men by the day, as is usual. Immediately afterward the contract for six more beds was let to a second man, who adopted the method of calling a certain number of loads a day's work, increasing the number as much as he thought the men would stand at each new bed. The result was that the cost per yard steadily decreased from 26 to 21½ cts., and the men usually went home happy between 2 and 3 p. m. The first man lost about 2 cts. per yard; the second man made a few cents per yard—in other words, the method used made the difference between success and failure.

Mr. E. P. Goodrich, M. Am. Soc. C. E., in a recent paper on reinforced concrete construction said: "The great point in arranging labor on a piece of work is to have an organization which will run like a clock. Such an organization will have no superfluous parts and will work with no irregularities of action." It seems hardly surprising to the average engineer that so many contractors lose money when he sees their work run with lack of forethought, wastefulness and mismanagement, rather than like well-oiled machinery.

THE VALUE AND DESIGN OF WATER POWER PLANTS AS INFLUENCED BY LOAD FACTOR.*

By Frederic A. C. Perrine.†

To one who has given even an elementary consideration to the problem of coal economy in a steam plant, the effect of load factor is at once apparent. The guarantees which are made in the contracts for steam machinery, and which are met in the plant tests are not realized as a matter of daily operation, excepting in the case of large pumping plants and steamships. The reason for this is not that there is a trick performed in the tests or that the machinery deteriorates rapidly after original installation, but it is due to the effect of the load factor.

Whenever the load factor is unity, the full economy realized on the test is also obtained in operation when the management is careful. But when the load factor is less than unity, periods are encountered when the load carried is not the most economical and, especially if there are periods when fires are banked, the coal consumption in proportion to the load is increased.

This matter is of such great importance that it is difficult with a load factor of 30% to reduce the coal consumption to less than 5 lbs. per KW.-hr. even though the steam apparatus at its most economical load will operate on less than 2 lbs. per KW.-hr.

This matter of load factor often affects the hydro-electric plant more seriously than the steam plant, though it is more generally true that the adaptation of plan to load factor is more often controllable in the design of the hydro-electric plant than in the design of the steam plant.

When the exceptional case of a unity load factor is encountered and at the same time the stream flow is constant, the plant and load are perfectly adapted to each other. This condition is to be found in certain of the Niagara plants and nowhere else. There the water flow is constant and the load is that of electrochemical industries whose load is closely controllable.

Where the load factor is less than unity and a stream providing no storage is furnishing the energy, energy is wasted whenever the load is less than the maximum capacity of the stream. On the other hand, when sufficient storage may be provided, a load having a factor of less than unity may be served without waste of hydraulic energy. Providing water storage for a variable load is the most direct method in design for attacking this problem.

After all has been done that is possible in obtaining the best possible storage and in selecting the most satisfactory customers, it is often the case that there remains a residuum in the problem which may be economically handled only by steam or gas auxiliaries. But a short time ago the presence in any hydro-electric system of steam or gas auxiliaries was considered a confession of weakness in the hydraulic system. Fortunately this false idea is fast losing ground and it is recognized that the best of engineering is shown by their use and in consequence fine hydro-electric opportunities are being utilized which were previously neglected.

Streams of comparatively constant flow, by the installation of steam or gas auxiliaries, are enabled to supply heavier loads than would be otherwise possible, though perhaps the most important use is found for auxiliaries in cases where the normal stream flow is very materially reduced during short periods of the year, by reason of special conditions in the water-shed.

No hydro-electric plant should at the present time be studied without considering the use of auxiliary power. Oftentimes such a study will result in the rejection of auxiliaries altogether. Oftentimes the employment of auxiliaries will, by the conditions shown, obviously be postponed to a later date than that of the original installation of the hydro-electric plant. But again, when it becomes apparent that auxiliaries are useful, it is immediately necessary to decide on the type of auxiliary installation most closely adapted to the conditions of water supply and loading. In some cases it is advisable to supply the constant load by steam or gas auxiliaries, which are installed in such a manner as to obtain the greatest possible economy of operation, and in such cases the variable load will be supplied from the hydraulic installation.

An unsuitable load is not necessarily one of a low power factor, but is one in which the curve of the load is different from the possible curve of output. Where the engineering of both plant and load can make the two load curves correspond exactly, the greatest possible output in revenue can be obtained from the hydro-electric plant, whether this be done by steam or water auxiliaries or solely by the engineering of the business department, in order to make the two curves correspond.

The common method of evaluating a water power plant is to state its cost or value in terms of dollars per unit of capacity, as we say that a plant is worth $100, $200 or $300 per KW. installed. This method of rating the value of a plant is only suitable where the supply possible from the plant is at a constant rate and the load factor of the customers' load is unity.

The true method of evaluating any plant, whether steam or electric is on the basis of the KW.-hrs. of output which are saleable, and in making this statement we should not by any means neglect the fact that a very considerable item in determining the value of a plant is necessarily based upon the intelligence of the management and of the engineer in establishing rates which will obtain a load adaptable to the possible supply. Following the lead of other stations which are operating profitably often results disastrously to hydro-electric installations, when these installations might have been made greatly profitable by a proper adjustment of the loading and charging.

It is much simpler to multiply the rate of greatest possible output by a round number of dollars, but this method gives no idea of what is the true value of the plant. To obtain a value worthy of notice it is necessary to obtain the possible load curve of the customers and from this determine the construction of the plant and its operating cost and then after a similar estimate has been made of the cost by steam or the best other competitive power, an evaluation may be made which is intelligible.

*Condensed from a paper read before the Franklin Institute.

†Construction Engineer, 60 Wall St., New York City.

THE LAKE AND GULF DEEP-WATERWAY project has received a set-back by the report of the board of engineers which has recently been submitted to the House Committee on Rivers and Harbors. This report estimates the cost of a channel from the lakes to the gulf at $63,000,000 to $70,000,000, and that a 14-ft. channel south of Cairo, Ill., would be so costly in comparison with any commercial advantages as to be out of the question. A 14-ft. channel from Lockport, Ill. (the end of the Chicago Drainage Canal), to the mouth of the Ohio River at Cairo, Ill., is estimated at $31,000,000. An 8-ft. channel would cost only about $10,000,000, and below Cairo a depth of 8 to 10 ft. could be maintained by the present dredging plants. An 8-ft. channel is therefore practicable, but a 14-ft. channel is considered impracticable. It is possible that a permanent 8-ft. channel would be worth $10,000,000, but it certainly could not be considered as a "deep waterway" and would of course be useless for the "ship canal" purposes which are so strongly urged by advocates of the waterway. Even a 14-ft. channel would be of little use for any but the smallest class of lake or sea-going vessels.

ELECTRIC HAULAGE OF CANAL BOATS has been extensively developed within the last year on one of the French canals near Donal. Electric locomotives operated by the current obtained by means of a flexible cable from an overhead trolley are run on a light track along the tow-path and haul the boats. Each boat can carry a load of 290 tons, and requires a tractive effort of 3 lbs. per ton to run it at a speed of 1.9 mi. per hr. At the pressure of 500 volts used, this takes 20 amperes. In order that the boats may pass one another they are fitted with a towing mast, standing about 30 ft. above the deck level. This mast, with the towing rope fastened to it, can be raised or lowered, and enables the tow rope to be kept clear of other boats and the approaches of bridges. When two barges come together, the master of the boat furthest from the tow-path keeps his mast raised, and the master of the nearer boat lowers his mast so as to allow the tow-rope of the former boat to pass over it. The rope from the mast is then changed from one of the locomotives to the other, which reverses its direction and proceeds in the direction from which it came, leaving the other locomotive free to take the other boat and do the same. The return circuit for the current is through the track rails. The track is of 40-lb. rails on wooden ties. To reduce the risk of the locomotive being tipped over into the canal by the tow-rope pull, the track rail next to the canal is elevated 1.6 ins. above the level of the other rail. Besides its use for haulage, electricity is employed at different points along the canal for operating cranes in warehouses and for working capstans used in working the boats into the locks.

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The water filtration plant at Youngstown, O., appears to be free from responsibility for the continued prevalence of a high typhoid fever death rate since the filters were completed and put in efficient working order. This conclusion is based on an official report recently made by Mr. Paul Hansen, Jun. Am. Soc. C. E., Assistant Engineer of the Ohio State Board of Health. The report is abstracted elsewhere in this issue. The mechanical filters at Youngstown were put in operation about the same time as were the slow sand filters at Washington, D. C., and at each place the introduction of filters was largely due to the high typhoid rates that had prevailed for some years past. The reports by Messrs. Horton and Sedgwick, in our issue of Nov. 8, 1906, indicated that other sources than the public water supply were largely to blame for the continued high typhoid rate in Washington, and Mr. Hansen's report points even more strongly to the same conclusion for Youngstown. In both cities, however, the filter plants were needed and appear to be doing all that could reasonably be expected of them.

It is almost past belief that the local board of health in any city of 60,000 people should have to await the results of an outside investigation before learning the essential and easily ascertainable facts bearing upon the causes for such high typhoid rates as have prevailed at Youngstown. The first task before Mr. Hansen, on arriving at Youngstown, was to secure from the local practicing physicians a complete list of typhoid cases since Jan. 1, 1906. His requests for this information were complied with by only 8 of the 98 doctors addressed, and two more requests brought in replies from less than half of the physicians. Telephone calls and personal visits finally secured returns from nearly all the doctors. This task accomplished, a canvass of typhoid cases was necessary in order to gain information for an intelligent consideration of the prevalence of typhoid in the community. Not only the list of cases, but also the desired information regarding each case should have been on file in the office of the local health board when Mr. Hansen reached Youngstown. Until the local boards of health of the country secure and make proper use of prompt reports on every case of typhoid within their administrative areas intelligent efforts to combat the disease cannot be expected.

The indifference of the Youngstown physicians to the requests of a state officer sent to investigate such grave typhoid conditions as have existed at Youngstown for years is a sad comment on the medical profession. Even more serious, because an epidemic is in progress, has been the failure of some of the physicians of Scranton, Pa., to report typhoid cases during the epidemic now prevailing in that city. Every one knows that the medical profession contains many self-sacrificing men, who devote no end of time and strength to the benefit of poor patients and the general public welfare. It needs to be even better known that in most communities a considerable percentage of the physicians are stumbling blocks and some of them absolute barriers in the path of sanitary progress.

Although receiving licenses to practice medicine and almost absolute protection from prosecution for even the worst of professional mistakes, many doctors are slow or entirely neglect to report communicable diseases, as required by law.

In a large part of the United States death and birth returns are frequently omitted by physicians, and in accuracy and completness of returning births and deaths nearly all physicians are deficient. Complete vital statistics, and immediate reports of all cases of communicable diseases, are essential to modern health-protective work. All this the medical profession as a whole should be the first to see and act upon, but with some notable exceptions it has thus far failed to live up to its opportunities and its duties. The responsibility for this failure, although primarily on the doctors, rests ultimately upon local and state boards of health, which can always bring moral force and in many States can bring legal force to bear upon any and all physicians who fail to report births, deaths and certain communicable diseases within periods laid down by statute or local ordinance.

A judicious and frequent use of moral suasion will make recourse to legal measures rarely necessary, but when necessary boards of health should be fearless in prosecuting the inexcusably careless or indifferent physicians, regardless of their professional or social standing.

High boiler pressure for locomotives was at one time widely advocated as a means of increased efficiency and has been very generally adopted, but there seems now to be a question whether it has not been carried to an extreme in some cases, and whether efficiency cannot be better obtained in some other way. Some experiments based on this line of thought were commenced on the locomotives in the mechanical engineering laboratory at Purdue University nearly 10 years ago, but as the funds available had to be employed mainly for purposes of education and instruction, the progress was slow until the Carnegie Institute gave a grant of $5,000 for carrying out research on this particular line. A report on these investigations has now been made by Prof. W. F. M. Goss, and his conclusions were presented in our issue of Nov. 22, indicating that the best and most economical results would be obtained by increased boiler capacity rather than by increased pressure, and that pressure of over 200 lbs. cannot be justified by any economy in performance. The discussions on the abstract of this report which was read before the Western Railway Club is given in condensed form in another column, and presents a number of points of interest, although in the main the speakers followed a line of thought not directly covered by the report. In most cases they discussed the merits of high and low pressures as applied in the boilers of existing engines, whereas the report dealt rather with points to be observed in locomotive design. This being the case, it is not surprising to find that several of the speakers, while approving in general of the suggestion of the advantages in lower pressures, did not consider it practicable to reduce the pressures on their engines and thus correspondingly reduce the power capacity of their motive power equipment.

While the report showed that the use of high pressure results in but small theoretical results and important practical disadvantages, the practice of employing high pressures was not without its advocates in the discussion. The idea presented was that the engine and boiler as a unit might be so improved as to develop both efficiency and economy at high pressures, while many details which now result in leakage losses and maintenance expenses under such pressures are capable of being made efficient for these pressures. Thus, in the item of packings for piston rods and valve stems, it was stated (and by an advocate of lower pressures) that such packing is in use which is steam tight and durable under 200 lbs. pressure. The possibility of a further improvement in the efficiency of the steam distribution system was also suggested, but it has been shown several times that the attainable results in this direction are very small as affecting the ultimate economy of the engine. One speaker stated very emphatically that for every pound of coal consumed in doing effective work in the firebox, two pounds are lost in the various stages of transmission from the mine to the firebox door. Evidently more might be accomplished by taking pains to save some part of the two pounds lost than by striving at the highest economy of consumption of the one pound that is put into the firebox, especially in view of the many conditions unfavorable to this highest economy of consumption in locomotive service. The conditions of weight and maintenance of boilers as affected by steam pressure were touched upon in the discussion, but always in relation to existing engines, and increased boiler troubles due to increased pressures were the experience of some speakers. On the other hand, engines with boilers carefully designed and built for 200 lbs. pressure and worked at 180 lbs. were found to be more economical in maintenance than boilers built for and carrying 160 lbs., even when allowance was made for the greater age of the latter. As far as weight is concerned, the proportion of weight of boiler to total weight of engine is shown to increase with the size of the engine, and to be from 30 to 40 lbs. per HP. The use of water-tube boilers for locomotives has been suggested, and a French boiler of this type, which was described in our issue of June 15, 1905, was stated to have a weight of about 22 lbs. per HP., but the practical introduction of this type of boiler into locomotive service is so far distant that it may well be neglected in practical considerations of locomotive economy.

In his remarks closing the discussion, Prof. Goss set aside the question of the comparative merits of high and low pressures in existing boilers, and summarized the matter as considered in application to locomotive and boiler design. The aim of the investigations was to show how a given or permissible weight might best be utilized and without any reduction in power. Thus, the use of the larger boiler for lower pressure would not mean a heavier boiler, but the weight saved due to lower pressure would be utilized in providing additional heating surface. This is clearly explained in the remarks by Prof. Goss, which we give, practically in full, with the abstract of the discussion on another page. The investigations thus far made relate only to simple engines using saturated steam, which class of course includes the great majority of the locomotives in use. It is hoped, however, that funds will be made available for extending the investigation to cover compound engines using saturated steam and simple engines using superheated steam. A report on the subject of the efficiency of high steam pressures in locomotive boilers was presented at the meeting of the American Railway Master Mechanics Association in 1898 (Engineering News, June 23, 1898), by a committee of which Prof. Goss was a member, and we quote below the conclusions of this report in regard to the question of boiler pressure and boiler capacity. We also quote the conclusions of the report of 1906, which we have been considering above, in relation to this same subject:

REPORT OF 1898.—The proposition to improve the economy of a simple locomotive by increasing pressure beyond present limits is of doubtful value. When viewed as one of several expedients which are open for

THE USE OF STEEL RAILS FOR ELECTRIC RAILWAY FEEDERS.

By Julius Alsberg, Jun. M. Am. Soc. M. E.

The present high price of copper has caused many engineers to believe that the time is ripe for the use of steel instead of copper for electric railway and power feeders. The writer recently had occasion to make conductivity tests of various steel rails, both for third rail and service use. The conductivity of these various rails was found to vary from 1/7.2 to 1/13.8 that of copper. The service rails had an average conductivity 1/9 that of copper, while some intended for third rail use were as low as 1/7.2. On the basis of these figures the writer made some calculations of the comparative costs of copper feeders and steel rails, which may be of interest.

It is evident that rails used for feeders must be placed either underground in a suitable conduit or upon insulated brackets similar to the ordinary third-rail construction. Whichever method is employed, two very important problems must be solved, namely, the insulation and the bonding of the rails. As regards the bonding, it is necessary to give the joints of the rails a conductivity equal to that of the unbroken rail. With the ordinary type of flexible copper rail bond this is very expensive, difficult to install, and impossible to maintain.

A bond of this type with expanded terminals would require the boring and reaming of four or more holes per joint, while the different expansion coefficients would sooner or later leave the copper terminals of less diameter than that of the holes in the rails. On the other hand, a soldered bond terminal would soon become poor on account of electrical decomposition of the soldering salts which are necessary to form a junction with iron or steel. The action of the current is to decompose the soldering salt into its component metallic and acid radicals. This acid radical is liberated on one of the surfaces of the bond contact and unites with the metal of that surface, forming a salt of that metal. The rate of corrosion will, of course, be proportional to the current transmitted, and will ultimately cause the bond to become detached.

If, however, the well-known Plastic rail bond be used, conductivity of the joints equal to that of the rail, and permanency, can be secured at reasonable cost. As for the insulation, this, too, can be secured at moderate expense by the method herein described.

This method was successfully employed in several instances where old rails were used for the return circuit from the service rails to the power station. It was found to be quite permanent. The general method consisted in placing the rails on insulators formed of large blocks of glass in a trough of rough boards. They were then bonded and the trough filled in with a hot petroleum residue compound. This compound remains viscous enough on cooling not to be brittle and has high insulating properties which do not deteriorate with time. After filling the trough it was closed with a board cover.

The cases in which steel might be employed for feeders naturally fall into two divisions: first, where new rails are used, and second, where old scrap rails are available. In the case of new rails, any shape that can be rolled in the mills may be selected at little or no extra cost. An L-shaped cross-section is believed by the writer to be most advantageous, as this allows of the use of a triangular shaped trough, the apex of the triangle being placed at the bottom and the base at the top. Such an arrangement requires a minimum amount of lumber, insulating compound and labor of installation.

This shape is also advantageous in bonding, as the end of one rail can be lapped inside the adjacent rail with the bond bolted between the metal surfaces where the rails overlap, two bolts sufficing to hold the ends together. This lapping of the rail ends and the consequent raising of every other rail would cause the trough to vary in size. But it is desirable to keep the trough the same size throughout its length, thus saving insulating compound and lumber. This can be accomplished by lapping the sections of the trough in the same manner as the rails. The writer has found it desirable to line the trough with tarred roofing paper to prevent the escape through the joints of any of the insulating compound. This might otherwise occur, owing to the well-known fact that almost all solid compounds of this nature will flow under their own weight.

Such an installation equivalent to a 1,000,000 c. m. copper cable, where the conductivity of the steel used is 1/7.5 that of copper, would require a rail having a cross sectional area of 5.9 sq. ins. and a weight of about 63 lbs. per yard. The cost per mile of such an installation using 30-ft. rails lapping 8 ins. at the joints would be approximately $3,868, depending, of course, on local conditions, prices, etc. Itemized costs are given in Table I.

TABLE I.—Cost per Mile of Feeder, Using New Rails and Equivalent to 1,000,000 c. m. of Copper.

53 gross tons of rails at $28 per ton		$1,484.00
18,000 board feet of lumber sawed to shape at $23 per M. board feet		414.00
720 glass insulators, 4 per rail at $0.25		180.00
40 tons insulating compound at $25 per ton		1,000.00
180 Plastic bonds at $0.50 each		90.00
Labor for excavating, bonding, filling in, etc		600.00
Heating compound, tar paper, bolts and incidentals		100.00
Total		$3,868.00

When old rails are available it is best to place the rail on the side with the base in a vertical plane, in such a manner that the flat base surfaces of adjacent rails lie against each other when lapped as in the previous case. Here again the Plastic bond can best be placed between the vertical bases of the two lapping rails, which are clamped together by two hook bolts. The trough will now have to be rectangular, and as alternate rails lie either to the right or left of the previous rail, the trough should be made to follow the rail in order, as in the case of the triangular trough, to save insulating compound and lumber. If, instead of one rail, two smaller rails are used, they can be placed on their sides, base to base, breaking joints in the rails.

Assuming that the old rails have a conductivity one-ninth that of copper, the cost per mile of an installation equivalent in conductivity to a 1,000,000-c. m. copper cable would be approximately $3,400, subject as before to local conditions, prices etc. Table II. gives the cost of the various items.

TABLE II.—Cost per Mile of Feeder Using Old Rails and Equivalent to 1,000,000 c. m. of Copper.

64¼ gross tons of old rails at $16 per ton		$1,028.00
22,000 board feet of lumber sawed to shape at $23 per M board feet		506.00
39.75 tons insulating compound at $25 per ton		994.00
Plastic bonds for 360 joints at $0.50 per bond		180.00
Insulators		200.00
Labor for excavating, bonding, filling in, etc		600.00
Bolts, tar paper, nails, etc		100.00
Total		$3,608.00

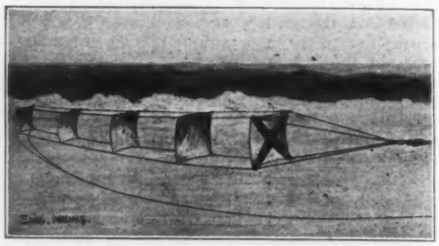
The cost per mile of a triple braided weather-proof flexible copper cable of 1,000,000-c. m. section would, according to a recent quotation, be about $4,800. Adding the cost of insulators, stringing of cable, extra brackets, pins, etc., the total outlay per mile of a 1,000,000-c. m. overhead copper feeder would be at least $5,200. In case a lead-covered insulated cable be used with underground conduit construction the cost would be very much higher.

Thus there is shown a saving, depending upon local conditions, etc., of about $1,300 per mile in the case of new rails, and of about $1,700 in the case of old rails. With the present high price of copper, where conditions warrant, it would therefore appear advantageous to use steel rails for feeders in place of copper cables.

A much greater saving is effected by the use of these steel feeders on an elevated railway structure. Here, as is the case on one of the Chicago elevated railways, the only expense in addition to the cost of the rails is the paraffin wood insulators or their equivalent used every 10 ft., and a separately supported plank covering above them. The feeders are thus between the two tracks, and the board covering furnishes a walk for the use of inspectors, etc. For third rail use, the same bracket, usually of cast iron, which supports the third rail, can be made slightly heavier and provided with extra insulators to support the feeder rail. I am told that the cost of these brackets is about 43 cts. each, and the cost of double insulators about $2.17 each. It is thus evident that steel rails are very much cheaper than copper at present prices.

A NEW SEA ANCHOR FOR USE WITH THE MILLER SYSTEM OF COALING SHIPS AT SEA.

In a paper read before the fourteenth general meeting of the Society of Naval Architects and Marine Engineers, Mr. Spencer Miller,* M. Am. Soc. C. E., described a new sea-anchor for use in coaling warships at sea. The Miller system of coaling at sea (Eng. News, April 5, 1900, p. 220), requires a sea-anchor to maintain a practically uniform tension in the sea-anchor line, while permitting the collier or battleship to plunge or roll or otherwse alter the distance between the masts of the two ships. The anchors used in the first experiments were of conical shape, constructed of flax canvas, stitched double, and had a length equal to the diameter. These anchors were found to be erratic in being towed through the water, diving, broaching and yawing. To prevent their settling to the bottom, they were provided with floats and, in order to get a more uniform tension and do away with the erratic motion, two anchors were used in tandem. These precautions proved very satisfactory, both as regarded tension and steadiness



Four-Foot Multiplane Sea-Anchor.
Space for storage, 24 cu. ft.; weight complete, 325 lbs.

of pull. In order to prevent the sea-anchor line becoming fouled by the rotation of the sea-anchor, swivels were placed between the sea-anchor line and the sea-anchor and between the tripping-line (line by which the anchor is drawn in) and sea-anchor.

During the Illinois-Sterling trials carried on in 1904, these sea-anchors did not prove satisfactory, as they were not provided with floats, and, therefore, dragged on the bottom of the sea in the shallow waters where these trials took place. The same anchors were, however, provided with floats and used in the Illinois-Marcellus trials, conducted off the Capes of the Chesapeake in May, 1905, and showed that such anchors worked satisfactorily and would stand the strain of being pulled through the water at a speed of 11 knots per hour.

A new style of sea-anchor, called the multiplane sea-anchor, consisting of a series of square canvas sheets spaced equal distances apart, has recently been tested in the Experimental Basin at Washington, D. C. These tests showed that with the same amount of canvas the multiplane sea-anchor will pull as much as the conical sea-anchor having a length equal to the diameter. That with five planes it will pull perfectly straight, there being no diving, broaching or yawing. Furthermore, it is cheaper and easier to construct, weighs less, requires less space for stowing, is easier to launch and recover, and, when provided with proper swivels, does not revolve while in use.

A sea-anchor of this style with planes 4 ft. sq., space 8 ft. apart, is shown in the accompanying figure. This anchor, provided with cork floats, was towed in a moderate sea off Sandy Hook by a tug at a speed of eight knots and showed itself to be superior in all ways to the conical anchor.

*Chief Engineer, Cableway Department of Lidgerwood Mfg. Co., 90 Liberty St., New York City.

grown to be uncertain. It is a fact, of knowledge to every railroad man, that in this day from two to three trains enter at times into every block of every system in the country. There is danger in it.

Whether Mr. Hill used these exact words or not, or whether he is really an authority on current practice in railway operating departments, makes no difference in the effect on public opinion. To the public mind, this deliverance by a great railway magnate like Mr. Hill is clinching evidence that the railways of the United States as a whole are conducting traffic in a reckless manner, whose direct result is daily exhibited in a long list of wrecks—so numerous that only those where a whole carload of passengers are sacrificed receive any notice in the daily papers.

Very likely Mr. Hill's indictment of American railway practice may be too sweeping, but that there is crying need of radical reform somewhere, the statistics of accidents furnished to the Interstate Commerce Commission by the railway companies themselves give ample evidence. We reproduce herewith two tables from the recently issued report of the Commission which give emphatic proof of this fact. It will be seen that while fewer passengers were killed in 1906 than in 1905, the number of passengers injured was greater than in any previous year, and there was a larger number of employees killed and injured. The recent epidemic of terrible wrecks makes it probable that the year ending June 30, 1907, will show a worse record than any previous year. That conditions are actually growing worse instead of better is further confirmed by the tabular statement of collisions and derailments. It will be seen that collisions increased from 6,224 in 1905 to 7,194 in 1906, and derailments grew from 5,371 in 1905 to 6,261 in 1906. These train accidents cost the lives of almost a thousand persons and maimed a whole army of nearly 12,700 more.

Surely, surely, surely, this record of death and disaster appeals most powerfully for remedial action of some sort. We have had a long trial of the plan of letting the railways conduct their business in their own way; and any unprejudiced person must admit that the plan is a dead failure. Casualties are increasing and not diminishing. The dangers of railway travel in the United States to-day are proven by statistics to be more serious than ever before. Our Wall Street railway kings are intent on deals and strategic moves, high finance and underground politics; but they are singularly blind to the fact that the reckless railroad operation of the day is creating a strong body of public opinion in favor of Government ownership, which must be reckoned with in the near future.

The true conservatives are those who are working for such a measure of Government control and supervision over railway operations as has been in successful operation for thirty years in England. The old plea that railway operations are private business is treated nowadays, as it deserves to be, with scant respect. The interest of the public in safe and efficient railway operation surpasses by far all other interests. Railway officials owe a duty to the public beyond even what they owe to the holders of railway stocks and bonds. Safety in operation ought to be a paramount consideration, and when an accident occurs, the public is entitled to know the facts, and all the facts. The day for secret star-chamber investigations of railway accidents by railway companies has passed. Those whose lives and limbs are at risk are entitled to know whether proper precautions are being taken for their protection.

It is true, of course, that the technical features of railway operation are beyond the grasp of the layman; but there is all the more need, therefore, of calling in expert aid and advice. In so far as any railway is conducting its operations with the best methods and appliances and maintaining a high standard of discipline and efficiency, it has nothing to fear and no reason for opposing Government supervision of its working. There will, therefore, be good reason to look with suspicion on any railways which try to defeat in Congress measures looking toward Government investigation of railway accidents.

LETTERS TO THE EDITOR.

New Standards in Engineering Literature.

Sir: Your editorial on "New Standards in Engineering Literature," in your issue of Dec. 27, hits the nail on the head. You give expression to thoughts which have been forced constantly upon the writer, and doubtless also upon hundreds of your readers who stand aghast at the ever-increasing flood of so-called engineering or technical journals and their contents.

Allow me to suggest one little reform which must be made in the interest of right orthography and etymology in engineering literature. Your leading article, p. 671, 2d paragraph, 5th line, contains a glaring misuse of words which has become so common of late that many of your readers must wonder how grammar is taught in our schools: "Had the closure not been affected."!!

Engineers, of all men, look for efficiency, effectiveness, effective results—in the above case a closure effected. They may indeed be affected by emotions of hope and fear, but their works are not so affected. Let us keep the affections in their proper sphere. This may strike you as puerile and elementary, but, as a fact, a paper sent to a leading engineering society by the writer, which was correct in the "copy," as to the use of effect and its derivatives, came back in the "proof" with the initial e changed to a, either by the type setter or editor.

Yours very truly,

Robert Fletcher.

Hanover, N. H., Dec. 28, 1906.

[Doubtless the original error was perpetrated by the typewriter—that Twentieth Century murderer of correct English; but the editors and proofreaders who ought to have caught the error can only plead the rush of work incident to the holiday time which doubtless *affected* their *effectiveness*.—Ed.]

Continuity and Cantilever Action in Reinforced Concrete Beams.

Sir: You have already answered the first point raised by Mr. Porter H. Franklyn, C. E., in your issue of Dec. 27, 1906.

As to the second point, the writer believes that with the usual methods of construction, and the relative dimensions of slabs and girders commonly employed, the designing of girders of T-section is entirely wrong, and that practically no advantage is or theoretically should be given by slabs as effective extensions of the compression area of concrete beams.

As to the third point, the writer always runs the majority of the bottom tension rods straight to the supports, thereby providing some steel in compression. Shear is cared for in other ways. The value of such compression steel is questioned, however.

As to the fourth point, the answer obviously is that greater stresses would be thrown into the main fibers. The writer has patched concrete beams at all vital points with perfect success; of course proper precautions were taken. The same could be done with work damaged as your correspondent suggests.

As to the fifth point, the writer finds less difficulty in placing steel near the tops of beams than near the bottoms, and with a much more certain knowledge of its location. Proper design will care for this point. The writer thinks the remarks of your correspondent under his fifth point are based on wrong premises. The earliest methods of design and the building laws based upon them assumed that concrete beams acted like beams of steel and wood. Later, it was learned that this gave excessive stregnth, and the matter was adjusted by allowing the use of the fraction "$^1/_{10}$." The latest step has been the discovery that concrete work is monolithic in its action, whatever its design may be as to arrangement of reinforcement. This monolithic action exacts the employment of reverse reinforcement to prevent dangerous cracking. Many buildings have become very unsightly (if not actually dangerous) from this lack, and in a few, extensive repairs have actually been carried out because of it. This condition of affairs is recognized in the latest building laws by the provision that "ample reinforcement is to be added to care for reverse moments." The framers of these laws are obviously over-conservative, because they still exact the use of the fraction "$^1/_8$" for beams and girders, after requiring the use of steel which makes this fraction unnecessary.

It is in view of these facts that the writer thinks your correspondent's "sole reason" for the attitude of building laws, viz., "the unreliability of placement of the top reinforcing bars" is primarily groundless, and is secondarily not the reason for the action of the building law framers as described by your correspondent. Consequently, it in no way offsets the advantages claimed for the cantilever type of design.

Yours truly,

E. P. Goodrich.

1170 Broadway, New York, Dec. 29, 1906.

Continuity Stresses in Reinforced Concrete.

Sir: Referring to Capt. John S. Sewell's article on the subject of continuity stresses in reinforced concrete structures, the writer's experience in design and observation in construction have led him to some conclusions differing considerably from those reached by Capt. Sewell. The theory of continuous girders requires unyielding foundations for its application. The author of the article recognizes this and bases his reasoning on the statement that "it is not usually impracticable to secure practically unyielding supports." Would not the statement be more in accordance with the experience of most engineers if the first negative were omitted? Continuous girders in steel have never been popular on this account, and the writer is of the opinion that the objection is still greater for the more heavily loaded foundations of concrete structures.

The unequal settlement necessary to cause excessive stress is exceedingly small, and it should be noted that the excessive stress may be thrown to the center of the beam or to the points over the supports, according to the location of relative settlement. The moment at the center of the span is thus very likely to exceed $\frac{1}{8}$ wl^2 on account of moment transmitted over the support. Of course the factor of safety can be loaded with all these uncertainties; but if the factor recommended

CASUALTIES TO PASSENGERS AND EMPLOYEES, YEARS ENDING JUNE 30.

	1906.		1905.		1904.		1903.	
	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.	Killed.	Injured.
Passengers:								
In train accidents	182	6,778	350	6,498	270	4,945	164	4,424
Other causes	236	4,407	187	3,542	150	3,132	157	2,549
Total	418	11,185	537	10,040	420	8,077	321	6,973
Employees:								
In train accidents	879	7,483	798	7,052	844	6,990	895	6,440
In coupling accidents	311	3,503	243	3,119	278	3,441	253	2,788
Overhead obstructions, etc	122	1,497	92	1,185	116	1,210	93	992
Falling from cars, etc	713	11,253	633	9,237	700	9,371	678	8,025
Other causes	1,772	31,788	1,495	24,842	1,429	22,254	1,314	20,759
Total	3,807	55,524	3,261	45,426	3,367	43,266	3,233	39,004
Total passengers and employees	4,225	66,709	3,798	55,466	3,787	51,343	3,554	45,977

COLLISIONS AND DERAILMENTS, DAMAGES TO CARS, ENGINES AND ROADWAY; YEARS ENDING JUNE 30.

	1906.				1905.			
	Number.	Loss.	Persons killed.	Persons injured.	Number.	Loss.	Persons killed.	Persons injured.
Collisions, rear	1,722	$1,720,365	169	2,427	1,493	$1,463,012	152	2,085
Collisions, butting	866	1,599,568	251	2,733	707	1,451,906	304	2,453
Collisions, trains separating	901	359,156	9	375	972	440,495	11	369
Collisions, miscellaneous	3,705	1,640,669	175	2,379	3,052	1,493,641	141	2,204
Total	7,194	5,319,758	604	7,914	6,224	4,849,054	608	7,111
Derailments due to defects of roadway, etc	1,287	918,056	38	1,608	1,007	777,433	59	1,446
Derailments due to defects of equipment	2,811	2,226,153	42	802	2,605	2,068,620	40	796
Derailments due to negligence of trainmen, signalmen, etc	391	318,067	54	494	341	272,254	40	419
Derailments due to unforeseen obstruction of track, etc	300	472,658	76	456	332	676,001	177	646
Derailments due to malicious obstruction of track, etc	65	106,859	18	94	76	142,761	34	196
Derailments due to miscellaneous causes	1,407	1,297,643	147	1,318	1,010	925,533	115	1,334
Total	6,261	5,339,431	373	4,772	5,371	4,862,602	456	4,838
Total collisions and derailments	13,455	10,659,189	977	12,686	11,595	9,711,656	1,064	11,949

adoption, it is manifestly not of first importance. For example, within limits now common, an increase in boiler capacity offers a way to increased efficiency which is both sure and significant. If, for example, it is desirable to increase the efficiency of a locomotive now carrying 140 lbs. of steam, by giving it a new boiler of the same dimensions with the old, but designed for a pressure of 200 lbs., the effect produced will be entirely due to increase of pressure. The economy resulting cannot be large, and may, as in the case of experiments already cited, amount to nothing. The new boiler may weigh, approximately, 5,000 lbs. more than the old. Now, it can be shown that if, instead of adding to the weight of the locomotive by making a stronger boiler, the same increase of weight had been applied to making a larger boiler, the resulting economy would not fail to be material.

REPORT OF 1906.—As a scale of pressure is ascended, an opportunity to further increase the weight of a locomotive should in many cases find expression in the design of a boiler of increased capacity rather than in one for higher pressures. Assuming 180 lbs. to have been accepted as standard, and assuming the maintenance to be of the highest order, it will be found good practice to utilize any allowable increase in weight by providing a stronger boiler to permit higher pressures. A simple locomotive using saturated steam will render good and efficient service when the running pressure is as low as 160 lbs. Under most favorable conditions, no argument is to be found in the economical performance of a machine which can justify the use of pressures greater than 200 lbs.

The regulation of electric railways by the railway commissions of the individual States has been frequently advocated, and is in force to a certain extent in a few States, but the electric railways have fought strongly against it, using the plea that old laws relating to "railways" apply only to steam railways and cannot be held as applying to a class of railways (electric) which was not in existence at the time of the enactment of such laws. The necessity for such regulation began with the adoption of electric traction for street railways, resulting in the extension of suburban lines and the increase in number of grade crossings. With the rapid development of electric interurban and cross-country lines, the demand for regulation has become more imperative. At first the principal trouble was in regard to the physical characteristics of grade crossings of steam and electric roads, the frequent passage of cars forming a serious danger to trains (accentuated by the liability of cars getting stalled on the crossing), while the protection of the electric cars by signals on the steam railway would be likely to interfere seriously with the operation of trains.

The danger is especially serious where traffic is heavy and trains pass at high speed, and is increased by the tendency to higher speeds for electric cars. In spite of the fact that it has been shown that an over or under crossing may generally be provided at comparatively small cost, eliminating all danger to and interference with the traffic of the roads concerned, and also eliminating the permanent cost of maintenance and operation of an interlocking plant, some electric railways have been very insistent in forcing the establishment of grade crossings with steam railways.

A new trouble due to the multiplication of electric railways is now being experienced by steam railways. This is the effect of wandering electric currents upon automatic block signals, and it is becoming more and more serious with the rapid extension of this system of signaling. This subject has been investigated by a committee of the Railway Signaling Association, and the committee's report, an abstract of which is given in another column, indicates that there is widespread trouble of this kind. The report recommends the passage of State laws empowering the State railway commissions to require such crossings to be so made and equipped as to eliminate the danger of interference with the signals of the steam railways. It also recommends that in agreements between steam and electric railways concerning grade crossings, the former should provide for ample protection of its interests according to requirements formulated by its engineers. Such methods would greatly relieve the situation, but there is still an element of trouble and danger which remains unprovided for; namely, that due to wandering currents from electric railways which parallel or approach the steam lines but do not directly interfere with them by grade crossings. There are already hundreds of miles of railway more or less closely paralleled by electric railways. In such cases it seems that the steam railways must very largely depend upon themselves for their protection, as there is little probability of the enactment of general laws requiring electric railways to provide efficient return circuits or making them responsible for trouble due to wandering currents. The signal engineers have therefore a double problem on their hands in protecting their signals from interference due: First, to currents at grade crossings where there is physical connection between the tracks of the steam and electric lines, and, Second, to stray currents from neighboring electric lines which have no physical connection with the steam line.

The latest attempt of a municipality to get valuable engineering advice without expense—to itself—is set forth in a circular letter sent to engineers by the "Board of Council of the city of Shelbyville, Shelby County, Ky.," under date of Dec. 17, 1906. The council named has created a sewerage commission, which is to submit plans and estimates for a sewerage system to the Council, and the Council will, in turn, submit the project to the voters of the city for ratification. The sewerage commission has decided "that the first step to be taken is to learn something concerning sewerage systems in general," and the plan it has devised to obtain this information is set forth in its letter as follows:

> To this end it invites those interested in devising plans, and designing public works of this character, and constructing such works—who may desire to do so—without hope of present remuneration, but who may feel sufficient confidence in the merits of their superior system or plan, to come to Shelbyville, view the city and its surrounding country, appear before this Commission informally, and present whatever views they may consider feasible and best, looking to the very best plan of sewerage for the city.
>
> The mind of this Commission may be said to be free and open to all plans, but its purpose is to get the best system of sewerage for the least money that the topography of Shelbyville may permit.
>
> When the Commission shall have had presented to it all the information that can be (which may include estimates and approximations on cost), it will be in position to make up its mind, and be ready to conclude its labors.
>
> Should you wish to take any interest in the matter, the Commission will be pleased to listen to what your representative may desire to submit before it in person, at Shelbyville.

Perhaps the commission does not realize that it is really asking engineers to educate it at their expense; but even if it does realize this and thinks its game a sharp one, we are confident it does not appreciate the fact that its circular letter is an open invitation to the crank, the quack and the swindler, and a warning to engineers and contractors of reputation and ability to keep away.

Would the same citizens who invite the engineering profession to come and make diagnosis and offer prescriptions, pursue such a course with the medical profession in case of illness in their families, or with the legal profession if an attorney's advice were desired? Can they not see that the one course is as foolish as the other?

There are just two explanations of this absurd circular letter. The one is that this sewerage commission is not really desirous of securing the services of reputable engineers or contractors, but wants instead to get in touch with some irresponsible and unprincipled concern, which will arrange for a liberal amount of graft in connection with the work. The other explanation is that the members of this sewerage commission are as ignorant as they claim to be—so ignorant that they have no conception of the fact that a sewerage system should be designed by a competent engineer. It looks easy to a layman to put in sewers. Nothing but digging ditches and laying pipe in them! Shelbyville can easily find contractors who will put in a "fine, up-to-date sewer system"—according to their promises—and the city will be at no expense for engineering advice.

This looks like a great stroke of economy for the taxpayers' benefit, and is perhaps hinted at in the commission's reference in its letter to "the best system of sewerage for the least money." There are plenty of cities which have tried just such economies in sewer construction and which are to-day up against the fact that they have spent hundreds of thousands or millions of dollars on sewer construction which is now worthless. The taxpayers who smile to-day in the delusion that they have saved a few thousand dollars in engineering fees, are likely to groan and curse 10 or 20 years hence, when confronted with the necessity of rebuilding sewers which were made too small to allow of future growth, or were laid with a view to cheap work rather than permanence.

There is no more common delusion than the idea that it is possible to get something for nothing; but the people who follow this delusion are apt to find themselves the owners of a gold brick.

THE RENEWED DEMAND FOR GOVERNMENT INVESTIGATION OF RAILWAY ACCIDENTS.

The three terrible railway collisions which occurred last week have again directed public attention to the dangers of railway travel and the crying need for greater precautions to secure safety. In the outskirts of Washington, D. C., on a foggy evening, a train of empty cars plows into the rear of a crowded local passenger train, killing 60 persons and maiming as many more. In central Kansas, three days later, two Rock Island express trains meet in a butting collision and 34 corpses are removed from the wreck. A few hours later a rear collision occurs near Omaha, Neb., between two transcontinental express trains on the Union Pacific, and the engine of the following train telescopes an observation car on the rear of the train ahead, killing three passengers and injuring a dozen more.

A month ago in these columns we made an urgent appeal for the establishment of a Government Bureau to conduct investigations of railway accidents through a corps of experts. That this will be done at the present session of Congress seems now altogether probable. The killing and wounding of a train load of passengers almost within sight of the National Capital has done more to impress Congressmen with the need for action than all the statistical tables of railway disasters that could be gathered.

Already Representative Morrell, of Philadelphia, has introduced a resolution ordering an investigation by a Congressional committee of recent train wrecks to the end that the Interstate Commerce Commission may be given greater authority over railway operations. The Commission itself is undertaking an investigation of the wreck at Terra Cotta, and has issued an appeal to Congress requesting authority and an appropriation to make experimental tests of automatic devices to prevent railway collisions.

Under these circumstances, it seems impossible that opposition by the railway interests will be exerted to prevent the establishment of Government investigations, or that if it is exerted it can defeat the strong public demand.

For the public has lost all confidence—if it ever had any—in the railway companies, investigation of their own wrecks. It is not satisfied with the published information that fifty lives were blotted out because a signalman blundered here or a locomotive runner made a mistake there. It wants to know what checks are in force, here or elsewhere, to guard against such blunders. It wants to know whether engineers are given a printed rule that the block signal at danger is not to be passed under any conditions, and are privately instructed that it is permissible to take chances so long as their train is "under control," which may mean and often is interpreted to mean a speed of 30 miles an hour or more. It wants to know whether those who travel by rail are entrusting their lives to men who may have been working long hours and be drowsy from lack of sleep when they should be alert to watch for a signal. Already it has been found that the engineer of the locomotive which telescoped the train at Terra Cotta had had only eight hours sleep in the 48 hours preceding the disaster.

If anything further were needed to unsettle public confidence in the safety of railway travel under present conditions, it has been furnished by the widely published statement attributed to Mr. Jas. J. Hill in the New York "Sun." We quote it as follows:

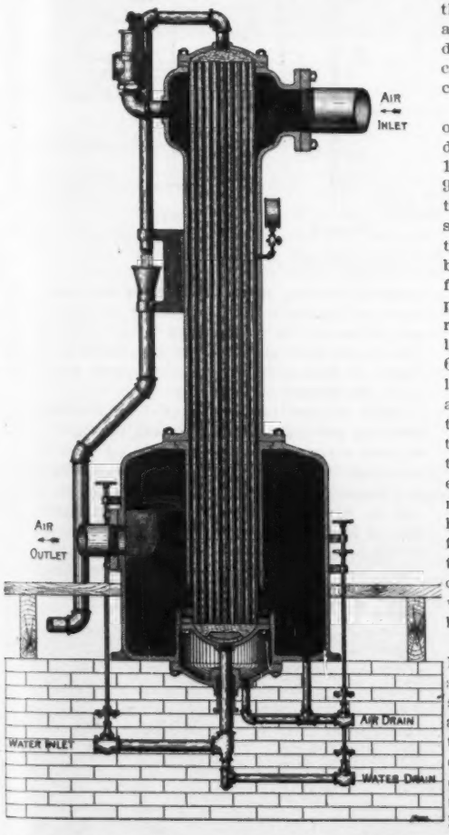
> Every time I undertake a railroad journey nowadays I wonder whether it is to be my last. The thing has

uneven settlement of the pipe. Three sections of 42-in. pipe coupled together and tested as a beam, failed through the shearing of the rivets in the circular bands and not by shearing or pulling apart of the joints. The pipe was 8 ft. 3 ins. long c. to c. of supports, 4⅜ to 4¾ ins. thick, and of the construction described in our issue of March 8, 1906. The pipe was loaded with pig iron and fracture occurred with a load of 28,320 lbs., by shearing rivets in the circular bands and breaking one of these bands. Longitudinal cracks at top and bottom occurred with 17,500 lbs. and 217,000 lbs., the pipe being kept from collapse by the reinforcement. Previous to collapse the deflection at the center was ⅝-in.

The Cartlidge reinforced concrete culvert pipe described and illustrated in the same article (above noted) has been patented by Mr. C. H. Cartlidge, M. Am. Soc. C. E., Bridge Engineer of the Chicago, Burlington & Quincy Ry., who informs us that several thousand feet of this pipe have been made and have been found quite satisfactory.

A VERTICAL INTERCOOLER FOR AIR COMPRESSORS.

In our issue of Oct. 25 we illustrated a horizontal intercooler for multi-stage air compressors, made by the Allis-Chalmers Co. We show herewith a vertical type intercooler made by the Ingersoll-Rand Co., and used not only between the stages of multi-stage compressors, but as an ante-cooler and an after cooler, with single-stage machines. The air enters at the top and passes down the body among the thin brass cooling tubes, with only space sufficient for its free passage, thus securing intimate contact with all the tubes. The sides of the shell are continued by a petticoat down into the large settling chamber, and the air leaves the tubes near the bottom, rises in this chamber and passes into the upward-turned elbow leading to the outlet.



A Vertical Type of Intercooler for Air Compressors.
Made by the Ingersoll-Rand Co., New York City.

The water enters the tubes at the bottom and overflows at the top, keeping the tubes always full. The upper head in which the tubes are fastened is held securely by the cap bolted over it. The lower tube head is free to slide vertically to avoid all strains of expansion or contraction, the water pipe being led in through a stuffing box. The tubes may be taken out without moving the body; and if the joint is broken at the top of the settling chamber, not much height is required for the lift. The capacity of the lower chamber gives it considerable value as an air receiver, although it is not intended that the usual air receiver shall be dispensed with.

A NEW UNDERGROUND RAILWAY IN LONDON, ENGLAND.

The Great Northern, Piccadilly & Brompton Ry. is the latest of the numerous underground deep-level "tube" railways of London, England, and was opened to traffic on Dec. 15, 1906. It is longer than any of the other tube lines, having a total length of 9.75 miles, and has passages connecting some of its stations with those of other lines which it crosses. The western end of the line, in a suburban district, is on the surface. The depth of the tunnels below the street level varies from 29 ft. to 123 ft., the tunnels being driven in the London clay. There are two single track tunnels 11 ft. 8 ins. diameter on tangents, 12 ft. on curves up to 660 ft. radius, and 12 ft. 6 ins. on sharper curves. They are lined with cast iron segments, which are covered by a concrete lining to a height of 2 ft. above the rails, in order to prevent any accidental contact being made between the lining and the conductor rail. The station tunnels are 21 ft. 1½ ins. diameter. The grades are so arranged at stations as to assist in stopping and starting the trains; the trains approach each station by an ascending grade of 1 in 66, and leave it by a descending grade of 1 in 33. There are three cross-overs connecting the two tracks, and the curves are in general of 1,320 ft. radius.

The track construction is very similar to that of the Baker St. & Waterloo Ry., which was described in our issues of Aug. 2 and Sept. 6, 1906. The track rails are of bullhead section, 90 lbs. per yard, carried in 30-lb. iron chairs attached to ties of Australian karri wood by lag screws, with a layer of felt between the chair and the tie. The rails are spliced with plain splice bars, 18½ ins. long for the outside and 16½ ins. for the inside, with four $^{13}/_{16}$-in. bolts. Each pair of splice bars weighs 28 lbs. The conductor rails are of rectangular section; they weigh 85 lbs. per yard and have an electrical resistance 6.4 times that of copper. The positive rail is laid close to the concrete lining of the tunnel, and the negative or return rail is between the track rails. The ties rest on a concrete foundation somewhat narrower than the gage of the track, with granite ballast tamped under the ends of the ties. The trains are made up of motor cars and trail cars, each of the former having two motors of 200 HP. The fares are from 2 to 8 cts., according to distance, and the trip of 9¾ miles will be made in 37 minutes, including about 20 intermediate stops. The trains will run at intervals of 1½ minutes during the busy hours.

The stations are served by Otis electric and Musker hydraulic elevators, and in one of the shafts at the Holloway station a Reno traveling spiral platform has been installed experimentally. This is double, so that passengers can travel in either direction, and moves at a speed of 100 ft. per minute. The moving surface is composed of teak treads carried in steel chains running on wheels upon a spiral track. A flexible handrail travels at the same speed as the tread or platform.

The tunnels are ventilated by 19 fans, placed in buildings at the surface and connected with the tunnel by ducts of 16 sq. ft. cross-sectional area. The fans are 5 ft. 6 ins. diameter, driven at 250 revolutions by electric motors of 10 HP. Each fan draws 18,500 cu. ft. of air per minute from the tunnel, discharging this through a shaft extending above the buildings. The power is obtained from the Chelsea power station of the Underground Electric Ry. Co., which owns this road and two other similar roads. This station has steam turbines and Westinghouse generators of 5,500 KW., producing three-phase alternating current at 11,000 volts, 33⅓ cycles. There are three substations, where the alternating current is converted to 550-volt direct current.

The signaling equipment is of interest, and consists of automatic block signals; there are four signal cabins for the manual operation of interlocking plants, while at each of the three crossovers is a cabin which will only be used when trains have to be switched. The Westinghouse electro-pneumatic automatic signals are used, the air being supplied by a main pipe carrying a pressure of 60 to 70 lbs. The track circuits are well protected, and all signals (including those worked from the cabins) are controlled by the track circuits; thus the manual signals cannot be cleared until released by the circuits and are automatically returned to the "stop" position. There are no ordinary distant signals, but where the view of a signal is obscured, a repeater is used in advance which shows a yellow light when the main signal indicates "stop." This signal may then be passed with the train under control, ready to stop if the main signal has not been changed to "clear." There are no semaphores in the tunnel, the signals having only the spectacles, with red and green lenses. All the signals have Adlake long-burning lamps, which can be left for a week without attention.

There are 84 automatic signals, 72 semi-automatic or controlled signals and 37 repeater signals. Each regular block signal has an automatic stop; this consists of a trip which is operated from the signal circuit by a small motor and engages a lever on the motor car (if the latter should pass a signal indicating "stop") and so applies the brakes. Some of the signals at the open-air end of the line have automatic fog-signal devices, each operated by a small motor. This device places a torpedo on the rail when the signal is at the "stop" position. It is placed in advance of the signal, so that a train running slowly in a fog can be stopped between the torpedo and the signal (with its automatic stop). Mr. James R. Chapman is Chief Engineer of the Underground Electric Ry. Co., which, as noted above, owns three of the London tube lines.

CONCERNING THE 102-FT. REINFORCED CONCRETE ROOF GIRDERS IN A LOS ANGELES WAREHOUSE.

In our issue of April 20, 1905, we illustrated the largest span yet attempted in reinforced concrete girder construction, being a warehouse with a roof of 102 ft. span at Los Angeles, Cal. Since that time this structure has been frequently referred to as an important precedent.

Reports have recently reached us that these large girders had cracked and columns had therefore been placed underneath them. An inquiry from the engineer who designed the structure as to the actual facts has brought the following response:

Sir: Answering your favor of recent date in regard to the cracks in the warehouse for Carl Leonhardt, in Los Angeles, Cal., I will say that this building was originally designed to be of 12-in. brick walls, flimsy iron trusses and corrugated iron roof, and the owner made a demand upon me to design a building to come within the price of the above construction, and I therefore assumed a factor of safety of about 2 in the construction, temperature stresses being considered.

I understand that at the end of March, 1905, the centering of the 100-ft. girders was removed and that they deflected only ¼ in. The fact is that the big girders, including their supports of 23 ft. height, were designed as an arch without hinges, and it is very probable that the action of the sun, acting on the unprotected sides and roof of the building, caused such temperature stresses as to crack some of the girders about 6 ft. from the support, and to deflect the column, which is really one monolithic stone with the girder, from one to two inches in a height of about 23 ft. This effect of the temperature was discovered about four months after the centering was removed. The owner investigated the effects of the change of temperature and found that the average rise and fall of the girders is about ½-in. from noon to midnight.

I saw the building last about the middle of March, 1906, and found that the owner had placed one wooden support under some of the girders, sub-dividing the span into about 80 ft. and 20 ft., but on my investigating these supports I found that they were all loose and as a matter of fact not one of the girders was supported. The cracks in the girders cannot be seen from the floor but only on close scrutiny.

Cracks in a concrete roof are rather the rule than the exception and I myself have seen very few concrete

by Capt. Sewell in his paper before the International Engineering Congress at St. Louis, Mo., viz. 2.5, be used, the writer does not approve of loading this small factor with too many uncertainties. Hence the writer's practice has been to figure the center of span for $\frac{1}{8}$ wl^2 and the reinforcement over the supports to bear $\frac{1}{10}$ wl^2. This may appear excessive; but it will not of itself result in a crushing of the concrete due to excessive reinforcement, and it will result in a good distribution of the cracks.

In regard to a small amount of reinforcement over the supports being a detriment, tending to cause cracking in the clear span instead of over the supports, it would seem that if the beam is built continuous, the cracks are very unlikely to open directly over the supports in any case for the reason that directly over the supports the lever arm of the tensional strength of the concrete is practically infinite. The weak point is thus not over the supports, but adjacent thereto.

Cracks are therefore more likely to occur at the point where the beam first bears on the support; and hence at the point of greatest shear. Cracks would be less dangerous at any other point; hence, any reinforcement over the supports is of value. It is also of value because it will cause a distribution of the cracks and a compression on the bottom of the beam, thus reducing the probability of failure by shear.

This subject is intimately connected with that of shear and brings out the necessity of reinforcing for shear with inclined bars, no matter whether the shear on the concrete section figures small or not.

The writer's experience in design has taught him to be constantly on the lookout for continuity stresses. They occur in the corners of culverts and retaining walls, in the floors and fronts of buttressed retaining walls, and, in short, wherever there is a support in the body of the structure, against any force. Text books on reinforced concrete often contain designs wherein the continuity stresses are not provided for.

Very truly yours,

A. H. Perkins.

Engineer, Reclamation Service, Huntley, Mont., Dec. 12, 1906.

Railway Companies and Railway Accidents.

Sir: I wish to commend the stand you take in the matter of having thorough and unprejudiced investigations of all railroad accidents. My short experience of seven years in the railway service has proven to me that one-half has not been told about the suppression of the truth from the public to cover up criminal negligence in railway accidents. Investigations by railroad officials are a farce. Even when the higher officials see that they are to blame, they keep it quiet and make no effort to remedy the causes, as that would be an admission of their own guilt.

I have met cold receptions and severe rebukes for discovering and reporting possible causes of accidents and asking that they be remedied. When a fatal accident happened from the cause pointed out as possible, a most severe rebuke was administered and I was advised that it was altogether out of place for me to report such matter in writing, because if the public should get hold of it the railway company would be liable for damages. The railway officers refused to remedy the defect and allowed it to stand for over a year a constant menace to the safety of traffic simply because to remedy it then would have been an admission of negligence.

Prevarication is a mild name for the information given to the public, and the result of investigations by railroad officials depends on the testimony of the most plausible and consistent liar who don't place any responsibility on the company.

Scores of drawbridges are to-day not protected any better than the one on which the Atlantic City accident took place. No thought of improvement is given to them either through pure conservatism and complacent self-satisfaction, as in the case of the Pennsylvania Railroad, or in some other cases because the officials consider it cheaper to pay for the accidents that occasionally happen than to invest several thousand dollars in installing adequate protection.

The taking of long chances pervades the whole railroad organization from the top to the bottom, and it is too common a saying among employees of the operating department that it is all right to ignore rules so long as they don't get into trouble by it.

The general manager takes chances in cutting down the allowances for operation and maintenance to a point at which he knows it is not possible to operate safely. The master mechanic allows boilers to run long after he knows that they are unsafe and should have been in the scrap-heap. The bridge engineer reports as safe bridges which he knows are unfit for traffic; the trainmaster sends out men on runs who he knows have not had sleep in 24 hours and are not fit to move traffic. The dispatcher, the operator, the engineer, the fireman, the conductor, the flagman, even the station porter and the track laborer all take long chances, and why should they not, for they have the example of the high officials and often their encouragement to do it; but woe to the poor section foreman who takes too many chances and gets his handcar smashed, or the flagman who allows a rear-end collision, or who has the audacity to commit "lese majesty" and try to put the blame on some fellow up the line of officials. Discharge and the blacklist is the punishment for him.

This subject needs vigorous agitation. Life is held too cheap and its value measured only in the dollars and cents that the claim agents have to pay for it, less the discount which the legal department can get on it by the law's delay. Something radical should be done, and your efforts to have investigations that will investigate and make public the reports of accidents should not cease until it is accomplished and the taking of chances with human life is entirely eliminated from railway operation.

Yours truly,

J. H. Eby, E. M.

Durango, Colo., Dec. 24, 1906.

The Bixby Hotel Collapse: Further Faults in Design and Execution.

Sir: In the reports of different engineers on the recent failure of the Hotel Bixby, Long Beach, Cal., many of the numerous faults in the design of the steel reinforcement have been discussed, but I have noticed several additional weak points in this building, as constructed, which may be of interest to your readers.

The four ½-in. round reinforcing bars of the columns were specified to be placed in the corners, 2 ins. from the face of the concrete, and tied every 16 ins. with a No. 7 wire. In construction these bars were placed in various positions, oftentimes being located near the center of the column, and were in most cases wrapped with a single strand of No. 10 wire every 20 or 24 ins. in height. As the fourth-story columns, at the time of the accident, were loaded with at least 650 lbs. per sq. in. in addition to the moving load of the 1,000-lb. concrete cart, it is evident that the factor of safety of these members was very small.

I was informed, by two foremen employed on the work at the time of the catastrophe by sub-contractors, that it would be shown in the future damage suits that the contractor was removing a column in the fourth story, and that it was the failure of the two 4 × 4-in. pine struts which formed the temporary supports for the fifth floor and roof at this point that caused the collapse. Of course this is a rumor; but as it is generally known here that columns were removed in this manner on other occasions, the report may be well founded.

The concrete used in the fifth floor was not of the same grade as that of the lower floors. Its very poor quality having attracted my attention, I secured some samples which I tested in a compression machine several days ago, at which time the concrete was at least seventy days old. In no case did the compressive strength reach 1,000 lbs. per sq. in., and a fair average would be 700 lbs. per sq. in.

There are at the present time about eight girders which have developed diagonal shear cracks near their supports, from their own weight. However, it is claimed by the contractor that these girders have since been loaded with their full live load without showing any further cracks.

The entire omission of any reinforcement to take care of the shearing stresses in all beams and girders, the poorly-designed column reinforcement, and the lack of steel to bind the building together are probably the weakest points in the design of this building. In construction, poor supervision was everywhere apparent. The forms were poorly made, the reinforcement carelessly placed (in most cases the Kahn bars in the beams being laid directly on the forms), the concrete in the beams was often poured long before that in the floors, and frequently the work was stopped when a portion of a girder had been poured.

It is to be regretted that a building of this size and character should be constructed without the assistance of proper engineering ability, and it is to be further regretted that the work of completing the building should be undertaken without such assistance. In the fifth story of the east wing, which is now under roof, there are two rows of columns 18 ft. apart, supporting two girders running the full length of the wing, which have no cross bracing whatever, unless the 2 by 6-in. pine ceiling joists which are supported directly on the above girders would be considered as such.

Even after this terrible accident which has happened so close to them, a number of owners here in Los Angeles are letting contracts for concrete buildings to be built according to the plans of the contractors, without consulting either architect or engineer. One of the buildings, I noticed yesterday, had the column reinforcement placed in a similar manner to that in the Bixby.

It is very apparent that unless the owners, architects and contractors are held criminally liable for all loss of life occurring through carelessness in not supplying sufficient intelligent engineering assistance in building reinforced concrete buildings, we will have more such terrible catastrophes as this one at Long Beach.

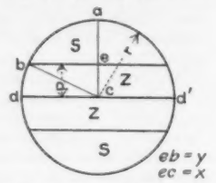
Albert C. Martin,

Engineer with A. F. Rosenheim, Architect.

Los Angeles, Cal., Dec. 27, 1906.

A Method of Dividing a Semi-Circle into an Equal Zone and Segment.

Sir. Having had occasion lately to divide a circle into four equal areas, two segments and two zones, as in the sketch, I am writing you for a suggestion as to how this result may be obtained by simple geometrical treatment.



I have arrived at it by application of the calculus as follows:

$$\text{Area } Z = 2\int_0^p \sqrt{r^2 - y^2}\,dy$$

equation of circle: $x^2 + y^2 = r^2$

$$= y\sqrt{r^2 - y^2} + r^2 \sin^{-1}\frac{y}{r}\Bigg|_0^p$$

$$= P\sqrt{r^2 - p^2} + r^2 \sin^{-1}\frac{P}{r}$$

$$\text{Area } S = 2\int_p^r \sqrt{r^2 - y^2}\,dy$$

$$= y\sqrt{r^2 - y^2} + r^2 \sin^{-1}\frac{y}{r}\Bigg|_p^r$$

$$= r^2\frac{\pi}{2} - P\sqrt{r^2 - p^2} - r^2 \sin^{-1}\frac{P}{r}$$

Equating the two areas:

$$2P\sqrt{r^2 - p^2} + 2r^2 \sin^{-1}\frac{P}{r} = r^2\frac{\pi}{2} \qquad (1)$$

Solving for P,

$$P = 0.403\,r$$

Sincerely, A. O. True.

Farmers' Bank Building, Pittsburg, Pa., Dec. 7, 1906.

[The following is a geometrical solution:

$$\text{Area } \triangle bco = \frac{xy}{2} = \frac{x}{2}\sqrt{r^2 - x^2}$$

$$\text{Area sector } bcd = \frac{r \text{ arc } bd}{2}$$

$$= \frac{r}{2}\sin^{-1}\frac{x}{r}$$

$$\therefore \frac{1}{2}\text{Area } Z = \frac{x}{2}\sqrt{r^2 - x^2} + \frac{r}{2}\sin^{-1}\frac{x}{r}$$

but $\frac{1}{2}\text{Area } Z = \frac{\pi r^2}{8}$ by problem

$$\therefore \frac{\pi r^2}{8} = \frac{x}{2}\sqrt{r^2 - x^2} + \frac{r}{2}\sin^{-1}\frac{x}{r}$$

which is the same as Eq. (1) above.—Ed.]

Notes and Queries.

Mr. F. C. Harper, 813 First National Bank Building, Chicago, writes:

I would be very glad to hear from anyone having any data on the cost of maintenance of track built for worktrains and construction work, in other words, maintenance of "construction" track. I would like to have it for any such track, but more particularly for that involving heavy worktrain traffic with fairly good speeds. Information regarding rails, ballast, tonnage, speeds, etc., on same, will also be appreciated. Do any books give any thorough information on this subject?

There are very few cases, we presume, where systematic cost records of maintenance on such track are kept. Even when track is laid for construction purposes only, as to a borrow pit or dump, it is seldom used long enough to have maintenance costs come down to a permanent and uniform basis. Usual practice is to do nothing in the way of maintenance so long as trains will stay on the tracks.

In the article on Concrete Pipe Culverts in our issue of Dec. 20, the titles to two of the cuts were transposed, that for Fig. 3 being put under Fig. 4, and that of Fig. 4 under Fig. 3. The mistake will be readily noted by anyone reading the article with care. The Reinforced Concrete Pipe Co., of Jackson, Mich., states that its pipe has been used for culvert and and sewer purposes under railway tracks, and to the best of its knowledge, there has never been any displacement at the points or

of a frame house reversed. The photograph Fig. 3 gives an idea of the appearance of the form work and how it was braced.

The construction plant is sketched in Fig. 7. Two mixers were provided—a Ransome and a Smith—but the former was used only a short time. These were placed about 10 ft. from the

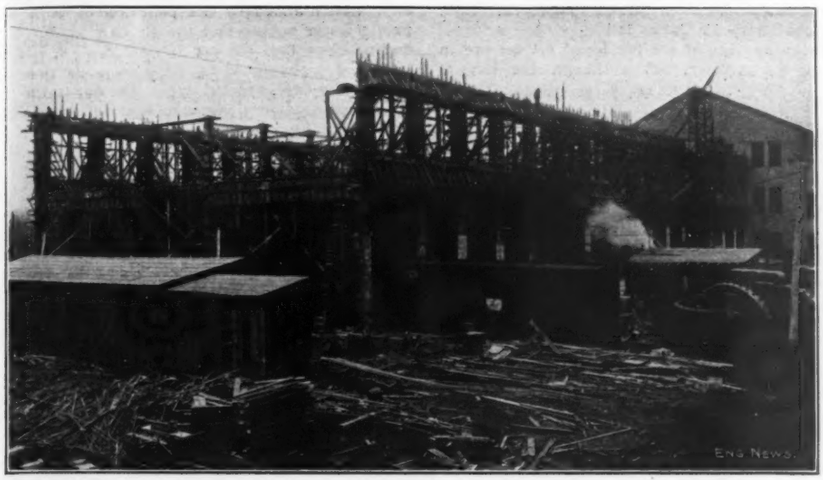


FIG. 3. REINFORCED CONCRETE EXTENSION TO SHOP NO. 3, BULLOCK WORKS OF ALLIS-CHALMERS CO., CINCINNATI, O., UNDER CONSTRUCTION.
The Ferro-Concrete Construction Co., Cincinnati, O., Designers and Builders.

building. Three large bins for sand and stone, and a cement shed, were built alongside the railroad siding. The materials were brought to the mixers by suitable runways, while Ransome bucket wagons were used to carry the concrete from the mixers to the hoists, one near each end of the building. Wheelbarrow runways were laid over the steel in place in the forms to allow the concrete to be readily carried to any part of the work. The carpenter shop equipment for the making of the forms comprised a circular saw and a planer, driven by an electric motor.

This shop was orginally designed to be built of structural steel. It was re-designed in reinforced concrete by the Ferro-Concrete Construction Co., of Cincinnati, Ohio, who also erected it.

REPORT ON THE PREVALENCE OF TYPHOID FEVER AT YOUNGSTOWN, O., AFTER INSTALLING WATER FILTERS.

The continued prevalence of typhoid fever in Youngstown, O., after a water filtration plant had been put in operation, led to an investigation of typhoid conditions in that city for some years past, and particularly during the first nine months of 1906. Mr. Paul Hansen, Jun. Am. Soc. C. E., Assistant Engineer, was assigned to the investigation by Mr. R. Winthrop Pratt, Chief Engineer of the Ohio State Board of Health. Mr. Hansen spent the period from Sept. 11 to Oct. 15, 1906, in a local study at Youngstown, and reported to Mr. Pratt on Nov. 21. We are indebted to Dr. C. O. Probst, Secretary of the Ohio State Board of Health, for a copy of Mr. Hansen's report. The main conclusions of the report are that the public water supply is not responsible for the present large amount of typhoid in Youngstown, but that it was largely responsible for the very high typhoid death rate that prevailed up to the close of 1904. Privy vaults, polluted wells, uncleanly living and food infection by means of flies are held responsible for a large part of the typhoid fever of 1906. In view of the general increase of typhoid elsewhere during 1906 and its falling off in Youngstown, it is believed that the filtration plant installed by that city in 1905 "has saved many lives."

As has been noted, Mr. Hansen devoted a little over a month to his investigation. Most of this time was spent in visiting the residences from which typhoid cases had been reported in 1906, and five of the latter days of the visit were used in collecting samples of water and making bacterial analyses.

The population of Youngstown is now about 60,000, a large part of which is engaged in iron and steel manufacture. Many of the mill hands "are foreigners and live in cheap houses, in unsanitary neighborhoods." As shown by Table I., Youngstown has had a high typhoid death rate and a low general death rate for a number of years past. Table II. shows that of seven large Ohio cities, Youngstown ranks highest in typhoid rate per 100,000, and in percentage of typhoid deaths to all deaths. "It has been generally believed," Mr. Hansen states, "that the public water supply was the prime cause of the excessive amount of typhoid" at Youngstown, "though it was recognized by some that other causes were also operative." The water supply of Youngstown is described in the report as follows:

> Until 1905 the public water supply was drawn directly from the Mahoning River. The river at this point is seriously polluted by sewage from Warren, Niles and Girard. In addition to this, the entire flow of the river is used over and over again by a number of steel plants. At the water-works intake the river has a very uninviting appearance as a potable water, being greatly discolored after its use in the steel mills and having usually an oily film on the surface. In 1905 a mechanical filter plant was installed and was placed in operation August 25. Regular records of the operation of the filter plant were not kept until March 12, 1906. Since that date the chemist and bacteriologist in charge has maintained regular daily analytical records of the raw and filtered water. The average monthly results are given in Appendix VI. (Table III.). It will be noted that the efficiencies have always been high and compare favorably with the results obtained from other filter plants throughout the country.
>
> It is not the purpose of this report to discuss the problem of filtration. The State Board of Health is at

TABLE I.—VITAL STATISTICS FOR YOUNGSTOWN, O., WITH SPECIAL REFERENCE TO THE TYPHOID FEVER DEATH RATE.

		Total deaths		Typhoid deaths	
Year	Population	All causes	Per 1,000	Total	Per 100,000
1893	36,700	516	14.05	8	21.8
1894	37,900	503	13.30	13	34.3
1895	39,000	543	13.90	11	28.2
1896	40,200	452	11.23	22	54.7
1897	41,400	463	12.60	20	48.3
1898	42,500	527	12.40	28	66.0
1899	43,700	664	15.20	54	123.5
1900	44,900	603	13.40	39	87.0
1901	47,400	701	14.80	59	124.2
1902	49,900	763	15.30	59	118.0
1903	52,400	842	16.05	79	150.6
1904	55,000	949	17.25	44	80.0
1905	57,500	969	16.85	30	52.2

[In October, the indications were that the typhoid death rate for 1906 would be about 42 per 100,000.—Ed.]

TABLE II.—COMPARATIVE TOTAL AND TYPHOID DEATH RATES OF EIGHT OHIO CITIES.

		Death rate per 100,000		Per cent.
City.	Period covered in years.	Total.	Typhoid.	typhoid in all deaths
Canton ...	1890-1904	11.02	42	3.8
Cincinnati .	1890-1904	19.28	51	2.6
Columbus ..	1890-1904	13.44	48	3.6
Dayton ...	1890-1904	14.87	31	2.1
Lima	1890-1904	14.38	39	2.7
Springfield.	1890-1904	13.47	45	3.3
Toledo	1890-1904	14.05	32	2.3
Youngstown.	1893-1905	14.33	76	5.3

[It should be noted that the Youngstown period begins three years after and extends one year after the periods for the other cities, and also that in the earlier part of the Youngstown period (see Table I.) typhoid was relatively low.—Ed.]

FIGS. 4 AND 5. TWO VIEWS IN COMPLETED EXTENSION TO SHOP NO. 3, BULLOCK WORKS OF ALLIS-CHALMERS CO., CINCINNATI, O.

roofs which have no cracks whatever, if these roofs are not protected by another roof, as, for example, wood or a layer of one foot of cinder concrete. Such small cracks in spans of 16 ft. to 20 ft. do not cause any uneasiness, but, of course, in a span of 100 ft. people get scared. I would not be afraid, however, to test each of these girders with a load of 50,000 lbs.

Yours truly,
L. J. Mensch.

Chicago, Ill., Dec. 20, 1906.

A REINFORCED-CONCRETE SHOP WITH STEEL ROOF-TRUSSES AND CRANE-GIRDERS.

By Wm. F. Tubesing.*

The Bullock shops of the Allis-Chalmers Co., at Norwood, Ohio, a suburb of Cincinnati, are of the common steel frame and brick wall type, but the latest addition to the works has been built of reinforced concrete. This addition, 107 × 230 ft. in ground plan, was put up in the remarkably short time of nine weeks. The contract under which it was built required the contractor to give a maintenance bond guaranteeing the design to answer the purpose for which it was to be used. Nearly a year has now passed since the building was put into service, and during this time it has given the best possible satisfaction to the owners. The present article describes briefly the design of this structure.

The drawing Fig. 1, showing a cross-section and a part side-elevation of the building, exhibits the arrangement of the structural parts completely. The three-span bents of columns and girders as represented by the cross-section are spaced 16 ft. apart on centers. The central aisle is 19 ft. 8½ ins. wide in the clear; the aisle on either side 39 ft. 9 ins. The structure has two stories. In the lower story each longitudinal aisle is designed to contain a runway for a 10-ton traveling trane. The crane-run girder is a steel plate girder, which rests on reinforced concrete brackets integral with the columns. The crane and runway are well shown in Fig. 5, a view in one of the side aisles of the ground floor. In the middle aisle the crane brackets were utilized to carry a mezzanine floor, used for a store-room. The building is of the skeleton type throughout, all loads except that of the ground floor being carried to the columns.

The columns are founded on spread footings reinforced with a grillage of rods. In Fig. 2 the details of the footings of interior and exterior columns are exhibited. These were designed to carry 335,000 and 219,500 lbs., respectively. A permissible soil loading of 5,000 lbs. per sq. ft. was assumed. The grillage rods are arranged in two layers at right angles to each other. The individual rods are shorter than the length of the footing in the corresponding direction; every other rod extends to within 2 ins. from one end of the footing, and the alternate rods are placed so as to extend within 2 ins. of the other end of the footing, as indicated in Fig. 2. This results in giving a steel area at the center twice as great as that at the ends.

The concrete of the footings is 22 ins. deep at the center and 4 ins. at the edges. From the top rises a short base section of column, extending up to 3 ins. from the finished floor line. This base section is reinforced with four vertical ⅜-in. square rods in the case of the wall columns. The superincumbent columns have four 1-in. round bars from the first to the second floor, and above this four ⅞-in. round bars in the wall columns and four ¾-in. round bars in the interior columns. The footing of an interior column has four 1-in. vertical bars with ¼-in. hoops, and to transmit the stress in these bars to the concrete a 3 × 3-in. plate is laid under each. The upper ends of the vertical bars project 7 ins. above the concrete to form a bond with the first-story column. In the case of the exterior or wall columns an additional means of centering is used. The top of the base section is recessed to a depth of 5 ins., forming a rectangular pocket just large enough to receive the base of the column above.

The remaining elements of the construction are sufficiently shown in Fig. 1, so that separate description is unnecessary. The wall panels are so reinforced as to constitute beams capable of transmitting their own weight and the weight of windows, doors, etc., to the columns.

The construction of the second floor merits special attention. The floor is a flat slab, 16 ft. in span, carried on girders running transverse to the building at each bent. The slab, 7⅞ ins. deep, is reinforced with ½-in. square bars 6 ins. apart, running from girder to girder. Of these alternate ones are bent up toward the supports, the others being straight. Three-fourths of the total number of bars extend over two panels. There is also a transverse or "shrinkage" reinforcing of ¼-in. bars, spaced about 30 ins. apart; these are in 36-ft. lengths, so that three of them end to end extend across the width of 107 ft. The slab was designed for a load of 225 lbs. per sq. ft.

The girders, designed for a total load of 280 lbs. per sq. ft., are reinforced as noted in Fig. 1. The main reinforcing bars are straight. The U-bars have variable spacing; for instance, those in the 40-ft. girders comprise four ½-in. bars at each end, spaced 8, 16 and 20 ins., and ten ½-in. stirrups equally spaced over the central portion.

The walls are 4 ins. thick, and are faced on the outside with a veneer of 4½-in. buff brick.

The roof framing, like the crane girders, is of steel, so arranged as not to bring weight on the concrete wall panels. The plan is to add a third story to the building in the future, and the steel roof permits of being raised for this purpose.

The mezzanine floor, in the middle aisle, is of wood on steel beams, and is carried by two 12-in. channels, held against the columns by bolts, supported by straps riveted to the channels and passing over the crane brackets of this aisle. An elevator and stair-well is located at one side of the building. It is enclosed by concrete walls. The stairs have steel strings and wooden treads. There is also a small elevator, about 4 × 5 ft., near the middle of the shop.

Some of the forms used in constructing the building are typically represented in Fig. 6. The column forms are made of sides of ⅞ × 5¼-in. matched lumber battened together; these sides are assembled by bands of 2 × 4-in. studs, which can be wedged together tightly. The bands are spaced 18 to 24 ins. apart vertically. The girder forms comprise a bottom piece 1¾ × 12, and sides built up of ⅞ × 5¼ matched lumber battened together by vertical 2 × 4's; 1 × 3-in. cross pieces under the bottom plank are nailed to the vertical battens to hold the three parts together. A 1 × 6 board, set on edge, is nailed along the outside of the battens in a horizontal line at proper level to carry 2 × 10 joists on edge for supporting the floor boarding on which the slab is placed. Each girder form rests on a block nailed to the side of the column form. The main part of the weight on the girder forms, however, is carried direct to the floor beneath by vertical shores, consisting of three 2 × 6-in. planks nailed together longitudinally to form a strut of I-section. The forms for the walls were built up much like the siding

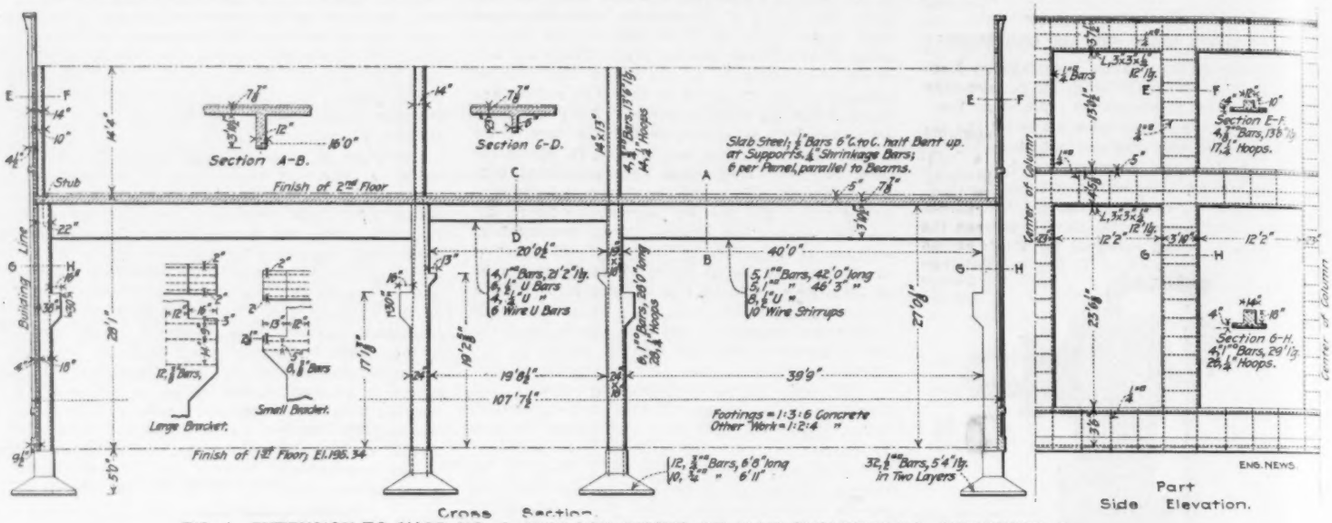

Section A-B.
Section C-D.
Section E-F
Section G-H
Finish of 2nd Floor
Finish of 1st Floor, El. 195.34
Stub
Building Line
Center of Column
Slab Steel; ½" Bars 6" C. to C. half Bent up at Supports. ¼" Shrinkage Bars; 6 per Panel, parallel to Beams.
4, 1" Bars, 21'2" lg.
6, ½" U Bars
4, ¾" U "
6 Wire U Bars
5, 1" Bars, 42'0" long
5, 1" " 46'3" "
8, ½" U "
10 Wire Stirrups
4, 1" Bars, 29'0" long
28, ¼" Hoops
Large Bracket.
Small Bracket.
12, ⅞" Bars.
6, ⅞" Bars
Footings = 1:3:6 Concrete
Other Work = 1:2:4 "
12, ¾" Bars, 6'6" long
10, ¾" " 6'11"
32, ½" Bars, 5'4" lg. in Two Layers
4, 1" Bars, 29'1" lg.
28, ¼" Hoops.
ENG. NEWS.
Cross Section
Part Side Elevation.

FIG. 1. EXTENSION TO SHOP NO. 3, BULLOCK WORKS OF ALLIS-CHALMERS CO., CINCINNATI, O.

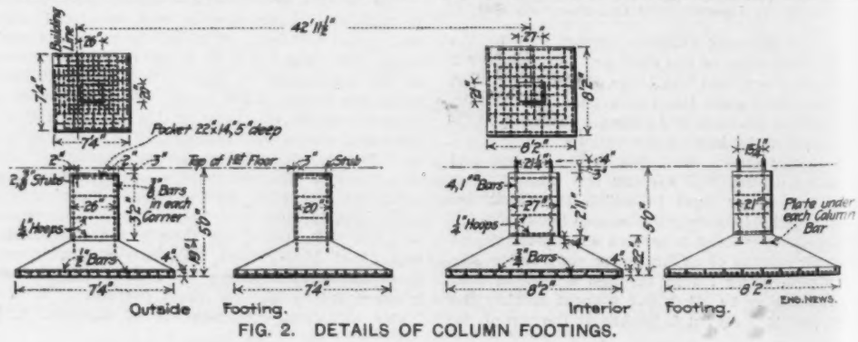


FIG. 2. DETAILS OF COLUMN FOOTINGS.

*2104 Kemper Lane, Cincinnati, O.

ection, emphasizes the necessity of continuing he rigid supervision of the filter plant that has btained since March of the present year.

(2) That a very large number of the locally nfected cases of typhoid are due directly or indirectly to the presence of numerous old-fashoned privy vaults and polluted wells.

(3) That much typhoid fever is brought about y uncleanly living and the consequent infection of food.

(4) That some cases of typhoid have been infected through the agency of flies carrying fecal matter from some near-by privy to kitchens in which food was being prepared.

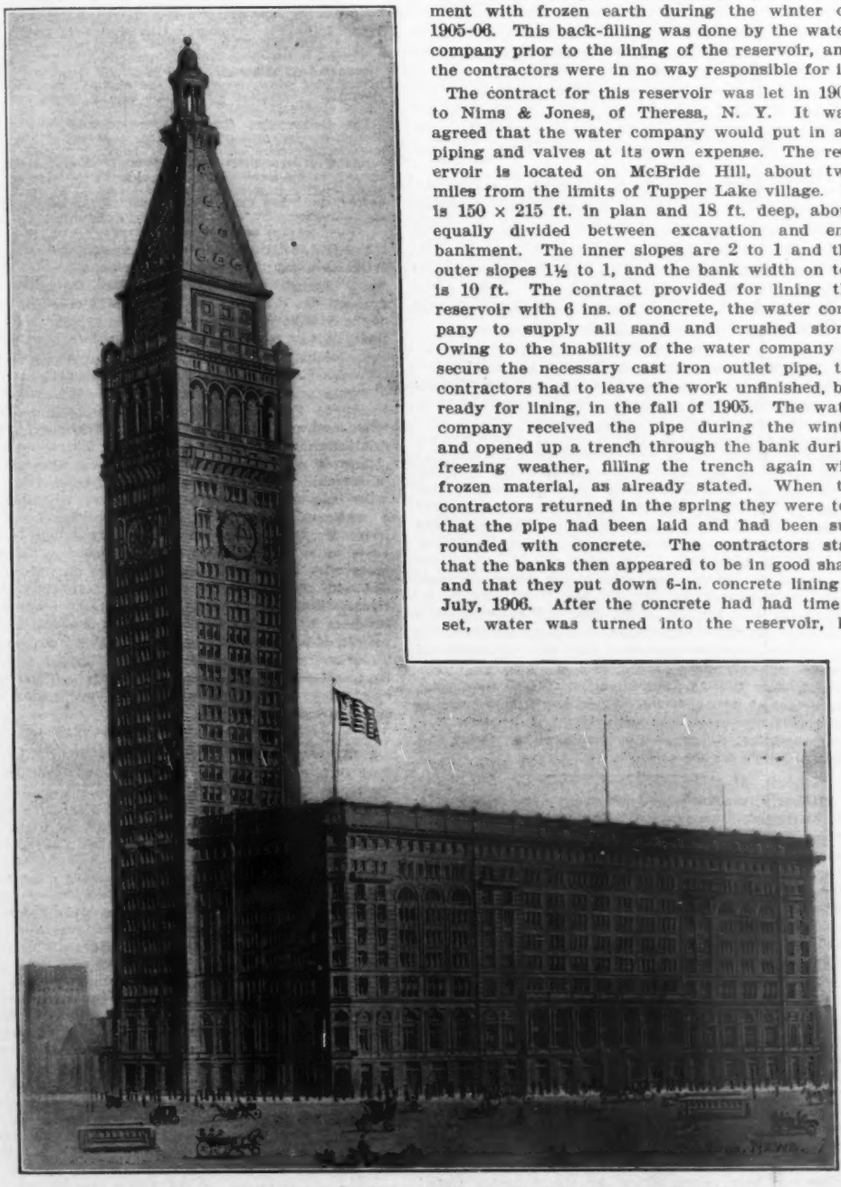
(5) That the prevailing increased typhoid death rate throughout the whole country during the present year, whereas that for Youngstown has fallen off, would indicate that the filtration plant has saved many lives.

THE HIGHEST BUILDING IN THE WORLD.

The distinction of being the tallest building in the world is one that any structure holds but for a short time. The new 41-story Singer Building, at Liberty St. and Broadway, New York, the foundations of which are still in the making, was up to the past week, the highest office building yet undertaken. Now plans have been submitted and excavations begun for a tower as an addition to the Metropolitan Life Building in Madison Square, New York City, which will have 46 stories and will be the highest building in the world.

The latter structure, a photograph of a model of which accompanies this article, is to be built as an annex to the eleven-story building already in use by the same company. From the top of the annex proper to a point 492 ft. above the ground, the tower will be 75 by 85 ft. in plan. Above that a pyramidal structure will extend 94 ft. high, the whole to be surmounted by an octagonal cupola 70 ft. high. The total number of stories will be 48 and the top of the cupola will be 658 ft. above the sidewalk.

The addition of this tower to the present building will give it a total floor area of 1,085,663 sq. ft. or about 25 acres. The architects are Messrs. Napoleon Le Brun & Son.



TALLEST OFFICE BUILDING IN THE WORLD. 48 STORIES, 658 FT. HIGH.
The Tower is to be erected as an addition to the existing building of the Metropolitan Life Insurance Co.

FAILURE OF A SMALL EARTH RESERVOIR AT TUPPER LAKE, N. Y.

The failure of the reservoir of the Tupper Lake Water Co., at Tupper Lake, N. Y., the latter part of December, 1906, is attributed by the contractors to back-filling a trench through the embankment with frozen earth during the winter of 1905-06. This back-filling was done by the water company prior to the lining of the reservoir, and the contractors were in no way responsible for it.

The contract for this reservoir was let in 1905 to Nims & Jones, of Theresa, N. Y. It was agreed that the water company would put in all piping and valves at its own expense. The reservoir is located on McBride Hill, about two miles from the limits of Tupper Lake village. It is 150 × 215 ft. in plan and 18 ft. deep, about equally divided between excavation and embankment. The inner slopes are 2 to 1 and the outer slopes 1½ to 1, and the bank width on top is 10 ft. The contract provided for lining the reservoir with 6 ins. of concrete, the water company to supply all sand and crushed stone. Owing to the inability of the water company to secure the necessary cast iron outlet pipe, the contractors had to leave the work unfinished, but ready for lining, in the fall of 1905. The water company received the pipe during the winter and opened up a trench through the bank during freezing weather, filling the trench again with frozen material, as already stated. When the contractors returned in the spring they were told that the pipe had been laid and had been surrounded with concrete. The contractors state that the banks then appeared to be in good shape and that they put down 6-in. concrete lining in July, 1906. After the concrete had had time to set, water was turned into the reservoir, but when it was about two-thirds full it was found that water was escaping along the discharge pipe. The contractors exposed the inner end of the discharge pipe for 24 ft. and found that the two joints thus shown were leaking and that the pipe was resting on wooden blocks with a void beneath them. They found only some 2 cu. ft. of concrete, placed around the intake end of the pipe. The water company had the two exposed joints recalked, and instructed the contractors to put concrete around the 24 ft. of pipe exposed by them. Accordingly, 18 ins. of concrete was so placed. The contractors advised that the pipe should be exposed and concreted for the remaining 50 ft. of its length, but the water company said that it would take the chances of further difficulty, watching for leaks as the reservoir was again filled. Owing to lack of water during the summer the reservoir, which is for reserve storage only, was not filled until late in the fall, whereupon the break occurred.

The foregoing information has been given to us by Mr. A. J. Nims, of Philadelphia, N. Y., a member of the contracting firm already named. Mr. Nims states that in justice to all concerned it should be noted that about the time the pipe was laid through the reservoir embankment the superintendent was seriously ill, and that the work in question was done when he was unable to direct the men who had it in charge.

From another source it appears that a gap was made in one corner of the reservoir bank, over the discharge pipe. The local explanation of the failure, presumably put forward by the water company, is that the concrete was faulty in places and allowed the passage of water through the embankment, undermining the latter.

DUTY TESTS OF HIGH PRESSURE PUMPING ENGINES AT MAHANOY CITY, PA.

Some duty tests were recently made at Mahanoy City, Pa., on a Worthington direct-acting low-duty compound (independent-condensing) pumping engine and a Snow high-duty horizontal, cross-compound, attached condensing, flywheel pumping engine. These tests are of interest as illustrating the great progress made in pumping engine practice since the Worthington compound low-duty engine was installed. In comparing the economy, due allowance should be made for the increased capacity and horsepower of the high duty Snow engine and the higher steam pressure which it uses. The general dimensions of the two engines are given in Table I.

TABLE I.—Dimensions of Pumping Engines at Mahanoy City, Pa.

Pumping engine.	Worthington.	Snow.
Number of high-pressure cylinders	2	1
Number of low-pressure cylinders.	2	1
Number of single acting plungers.	4	4
Diam. of high-pressure cylinders..	19¼ ins.	27 ins.
Diam. of low-pressure cylinders...	33⅜ ins.	60 ins.
Steam cylinder ratios.....	3.08	4.94
Diameter of plungers.....	12 ins.	10 ins.
Diameter of piston rods.....	3½ ins.	5 and 5¾ ins.
Designed length of stroke.....	24 ins.	42 ins.

The chief water supply of the city for domestic, railroad and colliery purposes is obtained by gravity, but the Mahanoy City Water Co. has a reserve pumping station located some six miles north of the city, for furnishing an extra supply in case of necessity. In this station, are located the above mentioned pumps, the water being forced by them through about 6,800 ft. of 14-in. pipe, under a static head of 827 ft. Until recently the pumping was done by the Worthington engine alone, but during the past year the Snow unit was installed.

The duty tests were carried out according to the code of rules for duty trials, as formulated by the American Society of Mechanical Engineers, the results being tabulated in Table II. The steam consumption as given relates only to the steam used by the engine and its condenser, as the steam used by the feed pump, leakages in pipes and boilers and moisture in the steam have been eliminated from the final results.

These tests were made by Mr. Jay M. Whitham, consulting engineer, 607 Bullit Building, Philadelphia, Pa., to whom we are indebted for the information.

present studying the operation of the Youngstown filter plant in connection with a special investigation of filter plants throughout the State, the results of which will be published during the following year.

To the sanitarian a very striking feature of Youngstown is the large number of shallow wells and old-fashioned vault privies still in use throughout thickly built-up portions of the city. The existence of the first is no doubt due to a general distrust of the public water supply, and the latter to the fact that no ordinance has ever been enacted making it compulsory on city property owners to connect with the city sewers.

The object of Mr. Hansen's investigation was to learn: (1) Whether the water supply was the source of typhoid infection and if not, then what

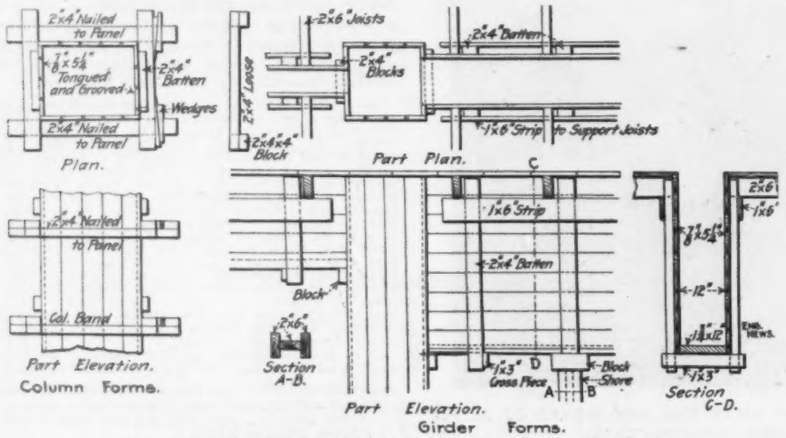


FIG. 6. TYPICAL DETAILS OF GIRDER AND COLUMN FORMS.

was. After outlining briefly and clearly the "generally accepted facts about the typhoid germ and typhoid fever," Mr. Hansen states that the first step in his investigation was to make a card record of each case of typhoid reported to the health department after Jan. 1, 1906. The cases were then platted on a city map, but were so scattered in area, as well as in time, as to give "no reliable indication of what was sought." It was then considered advisable to make a canvass to record all pertinent facts bearing upon the origin and control of each case, including water, milk, ice cream, celery, lettuce and raw oyster supplies, general sanitary condition of premises, whether house connected with sewer, whether windows and doors screened during summer, disposal and disinfection of excreta, etc.

Something less than half the typhoid cases having been reported by physicians, a circular letter was sent to the 98 practicing physicians in the city, requesting a complete list of all typhoid cases treated during the year, "with such other information as would throw light on the probable source of infection." Within 10 days only 8 of the 98 physicians responded to the letters. Two more rounds of letters brought the total replies up to only 48, or just under half. Subsequently telephone calls and a few personal calls elicited nearly all the required information.

A total of 208 cases were reported, of which 36 had been infected elsewhere and brought to Youngstown for treatment, and for 19 of which no reliable information was obtained. Of the 153 Youngstown cases investigated in detail, 93, or 60%, lived in houses not connected with the public water supply; 95, or 62%, were in houses without sewer connections; 109, or 71.3%, claimed to use well water only; 43, or 28.1%, claimed to use both the public water supply and well water; 1 claimed to use city water only; 28, or 18.3%, worked in steel mills; 64, or 41.8%, were in houses with poor sanitary condition; 52, or 34%, with fair, and 37, or 24.2%, with good sanitary conditions. Of the 153 cases, 5.2 were 0 to 4 years of age; 11.8%, 5 to 9; 29.4%, 10 to 19; 32.7%, 20 to 29; 11.1%, 30 to 34, and only 9.8%, 35 years or more of age.

Well waters appeared to have been the chief sources of infection. Nearly all the wells are "dangerously near privies." The public water supply was used exclusively, as stated, in one case, and in two other cases infection from any other source seemed improbable. But these cases occurred before the filtration plant was "placed under its present management, and before regular analytical records of the efficiency of the filter were kept." Moreover, less than two grains of alum per gallon were being used as a coagulant at the time these cases occurred, and examinations of the filter plant made by the State Board of Health show "that at least two grains" are required for "high efficiencies." A summary of the main facts relating to the operation of the filters from March to October, 1906, is printed here as Table III.

A large number of old-fashioned privies are in use at Youngstown, "even though the city is comparatively well sewered," and the "universal prejudice against the public water supply has caused the use of hundreds of shallow dug wells, nearly all of which are but 20 to 100 ft. from privies."

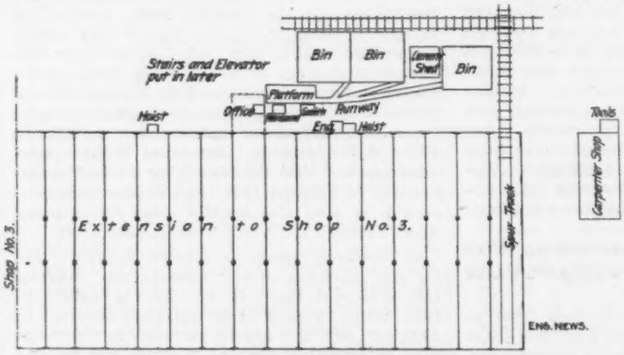


FIG. 7. PLAN OF CONSTRUCTION PLANT.

Analyses of water from a large number of shallow wells, combined with inspections of other wells, led to the conclusion

that many private wells are dangerously polluted, that a number of public and semi-public wells should be regarded with suspicion, and that several wells at industrial plants may be responsible for typhoid fever. It would be highly desirable for the local authorities to appropriate a sufficient sum to make possible the analysis of a large number of wells throughout the city and all those showing signs of danger should be at once closed.

Returning to the annual typhoid death rate at Youngstown (Table I.) Mr. Hansen calls attention to the low figures for 1893 (only 21.8 per 100,000) and the rapid increase from this date to 1903, when the enormous rate of 150.6 per 100,000 was recorded. The principal cause of the rise was doubtless the increase in the population of the city and of the Mahoning Valley above the city, which added to the pollution of both the public water supply and the shallow wells. The decline since 1903 (80 per 100,000 in 1903, 52.2 in 1905 and probably 42 in 1904) is attributed "in part to the care which a large intelligent portion of the population have exercised in securing a proper drinking water," which theory is supported by the fact that "but very few cases occurred among the upper classes." In addition "natural causes" (not specified) "operative throughout a large part of the country east of the Mississippi River should be credited with a portion of the reduction."

The distribution of typhoid cases by months shows no "definite law of variation," owing to the relatively small population involved, and the fact that the "peaks" might be due to small milk or shallow well outbreaks. The most prominent peaks occur the third and fourth months of the year and in the early autumn months. To aid in forming conclusions as to the effect of the public water supply and other causes upon the typhoid death rate, Mr. Hansen platted the average monthly typhoid death rates for the 13 years 1893 to 1905, expressed as percentages of the average yearly death rate for the same period, and also platted on the same diagram the average monthly temperature at Youngstown for the years named. The temperatures were taken two months in advance of the typhoid rates, in order to give time for the effect of the former on the latter.* The resulting diagram is reproduced herewith. The "rise in typhoid cases in the winter and spring months" appears to show "that during the 13 years considered a large number of typhoid fever deaths" were "due to the public water supply," and the peak in late summer "indicates conclusively that the city has always suffered from a considerable amount of typhoid fever due to general causes."

The conclusions of the report are as follows:

(1) That typhoid fever at the present time is not due to the public water supply, although in the past much was attributable to this source. The occurrence of a few cases during the early part of the present year, which seemingly point to the public water supply as the source of in-

*Mr. Hansen here followed the studies of seasonal temperatures and typhoid made in 1892 by Profs. Wm. T. Sedgwick and C-E. A. Winslow, as published in Memoirs American Academy of Arts and Sciences, Vol. XII., No. 5, pp. 521-71, with plates (Boston, 1902). A number of the diagrams in this paper are reproduced in Mr. Hansen's report.—Ed.

TABLE III.—OPERATIONS OF THE MECHANICAL WATER FILTERS, YOUNGSTOWN, O., MARCH TO OCTOBER, 1906, INCLUSIVE.

(Alkalinity, Color, Chlorine and Turbidity in parts per 1,000,000.

	March	April	May	June	July	Aug.	Sept.	Oct.
Gals. filtered water, estimated	5,631,000	5,000,000	5,462,354	5,704,000	5,719,000	5,808,480	5,658,600	5,492,400
Sulphate of aluminia used; lbs.	1,903	1,822	2,378	2,366	2,386	2,648	2,340	2,241
Grs. per gal.	2.365	2.46	3.00	2.97	2.99	2.97	2.83	2.82
Free carbonic acid	0.1	0.3	0.7	0.72	0.81	0.31	0.4	0.13
Alkalinity:								
River	56	53	78	115	111	71	91	50
Filtered	40	38	54	102	84	40	70	33
Color:								
River	132	182	156	116	148	231	239	239
Filtered	—1	0	0.5	0.4	0	13	0	4.9
Chlorine: River	7.3	5.8	3.4	5.8	3.7	1.7	4.4	1.5
Turbidity: River	436	51	32	28	67	103	60	59
Bacterial points per c. c.:								
River	40,895	13,852	17,907	176,300	78,968	63,630	58,940	22,920
Filtered	74	138	369	2,200	1,032	720	610	450
Per cent. reduction efficiency filters	99.82	99.03	97.8	98.71	98.69	98.73	99.23	98.03
B. Coli Communis River	22 of 22 samples no in	25 of 25 samples no in	yes in 19 of 21 samples no in	yes in 26 of 26 samples no in	yes in 25 of 25 samples no in	yes in 27 of 27 samples no in	yes in 24 of 25 samples no in	yes in 27 of 27 samples no in
B. Coli Communis Filtered	22 of 22 samples	24 of 25 samples	20 of 21 samples	21 of 26 samples	22 of 25 samples	18 of 27 samples	19 of 25 samples	20 of 27 samples
Cost per 1,000,000 gals. for coagulant	$3.38	$3.33	$4.33	$4.10	$4.25	$4.21	$4.21	$4.05
Percentage waste water	....	....	....	....	5.86	6.67	3.31	6.05

TRAINS IN THE RAPID TRANSIT TUNNEL to Brooklyn will be in operation by June, according to the engineers of the Rapid Transit Commission. They will first run from the Battery to the Borough Hall station in Brooklyn. It will be late in the fall, however, before trains will run up Flatbush Ave. to the Atlantic Ave. station of the subway. This delay is due to the great amount of work to be done at the junction of Flatbush Ave. and Fulton St. The station at this point is the largest of any on the subway system in Greater New York. There are five tracks on the same level and one track running under the others, making six tracks in all at this point. Two of the tracks are for connections with the Manhattan Bridge.

A NEW RAILWAY ROUTE across Nevada will be completed within a few weeks by the construction of the Bullfrog & Goldfield Ry., from Goldfield, Nev., to Bullfrog, Nev., being an extension of the Tonopah & Goldfield Ry., southeast from Goldfield. This latter line is about 100 miles long, connecting with the Southern Pacific Ry. at Mina, Nev. From Bullfrog there is the Las Vegas & Tonopah Ry. southeast to Las Vegas, Nev., on the San Pedro, Los Angeles & Salt Lake Ry. The three roads make a continuous line of about 310 miles, and have been built to develop gold mining regions. The Bullfrog & Goldfield Ry., now under construction, is 82 miles long, with an elevation of 5,700 ft. at Goldfield and 3,000 ft. at Bullfrog, while the maximum elevation above sea level is 5,884 ft., three miles south of Goldfield. The maximum grade is 3.37%, with a length of 1,300 ft., and the sharpest main line curve is of 12% for a length of 450 ft. The country is generally flat prairie country, and there are no important bridges or tunnels. The only heavy work is a sidehill rock cut 1,000 ft. long and with an average depth of 75 ft., and a rock fill 200 ft. long and 60 ft. high. The grading averages 8,000 cu. yds. per mile. All work is being handled by scrapers, no steam shovels being used. The width of roadbed is 16 ft. in cuts and 14 ft. on banks, and the track is laid with 65-lb. rails. The equipment will be similar to that on the Tonopah & Goldfield Ry., consisting of 150-ton locomotives of the consolidation (2-8-0) type. The train loads average 400 tons. The new line will serve nearly all the important mines in the Goldfield, Gold Mountain and Bullfrog districts, and it is expected to be completed by February. Mr. W. B. Chapin is Chief Engineer, and McLean & Ottman, of Tonopah, Nev., are the contractors.

BLOCK SIGNALS OPERATED WITH STORAGE BATteries are being installed on the Lake Shore & Michigan Southern Ry. from Nottingham to Chicago, a distance of 367 miles. Between Nottingham and Toledo the equipment is already in place. The average length of the blocks is 1 mile, and the entire work is being carried out in anticipation of there being four tracks throughout. The batteries are charged by line circuits from powerhouses placed at intervals of 15 miles. The motors for operating the signals on all four tracks are actuated by five cells of 40 ampere-hours' capacity. Independent batteries are provided for the track circuits, each track circuit requiring one cell of 120 ampere-hours' capacity. The batteries and instruments for the signals in each block are mounted in a cast-iron case near the signal pole at the side of the tracks. The lower compartments of the case contain the motor battery and the track battery, and in the upper compartment which is sealed against entrance of the acid from the batteries are located the switches and relays. Duplicate sets of batteries are installed for use in emergency and for alternate service while charging. Each charging plant comprises a 15-HP. Fairbanks-Morse gasolene engine belted to a Fairbanks-Morse generator giving 18 amp. at 550 volts. The track batteries require a charging current of 10 amp. at intervals of about seven days, and the motor batteries 5 amp. at intervals of about ten days. The Union Switch & Signal Co., of Swissvale, Pa., is doing the work under the direction of Mr. C. E. Denney, signal engineer, at Cleveland.

THE TWO SERIOUS RAILWAY ACCIDENTS in England last year appear on investigation to have been primarily caused by the enginemen of the wrecked trains, but in each case some slackness on the part of the railway management proved a contributing cause. In the Salisbury accident, the official report (published in our issue of Dec. 6, 1906) indicates that the engineman, through carelessness or forgetfulness, ran the train at high speed over a curve for which there were standing orders requiring reduced speed. The management appears to have been at fault in relying upon a somewhat perfunctory signing of the rules by the men going on duty to remind them of this particular curve. It was recommended that greater care should be taken in the future to definitely call the attention of men to special points of danger or to special rules affecting their trips.

In the Grantham accident, which was described in our issue of Oct. 11, 1906, another fast passenger train ran at high speed through a station at which it should have stopped, and was derailed on the sharp curve of a connection to a branch line. The official report states that nothing about the engine or train indicates a failure of the throttle or the brakes, and the conclusion arrived at is that the accident resulted from the sudden sickness or death of the engineman and the failure of the fireman to detect this, or the inability of the latter to get control of the engine in the emergency. In this case, the railway management is censured for not exercising a closer supervision over the health of the men in such positions of responsibility. The engineman had been absent for some time on account of sickness, but was not subjected to examination by a doctor on behalf of the company either then or on his return to duty. The official inspector recommends that an engineman who leaves his work on account of any form of sickness should be carefully examined by a doctor before being allowed to return to duty.

PERSONALS.

Mr. John M. Connolly has resigned as First Assistant Superintendent of Water-Works of Troy, N. Y.

Mr. J. Walter McMorrow, an assistant engineer on the Panama Canal, was married Dec. 27 at Ancon, Canal Zone, to Miss Beatrix M. Thomson.

Mr. T. C. Hughes, formerly Assistant City Engineer of Kansas City, Mo., has been elected City Engineer of Fulsa, I. T., at a salary of $1,500 per year.

Mr. Henry A. Van Alstyne, who retired as State Engineer of New York, Jan. 1, has become associated with the Atlantic, Gulf & Pacific Co., of New York City.

Mr. H. J. Roth, Assistant Superintendent of the Utah Division of the Oregon Short Line R. R., has resigned to engage in private business at Silver Creek, Neb.

Mr. E. O. Shively, Assistant Master Mechanic of the Wabash R. R., has been made General Foreman of Locomotives, and his former position has been abolished.

Mr. Joseph H. Hoadley, of New York City, has been elected President of the Alabama Consolidated Coal & Iron Co., to succeed Col. T. G. Bush, of Birmingham, Ala., resigned.

Mr. Geo. B. Herrington has been appointed Chief Engineer of the Georgia Southern & Florida Ry., with headquarters at Macon, Ga. He succeeds Mr. J. J. Gaillard, resigned.

Mr. A. W. Foster has resigned as President of the California Northwestern Ry., and the North Shore R. R., to enter private business. He became President of these roads in 1893.

Mr. J. S. Peter, Chief Engineer of the Chicago, Rock Island & Gulf Ry. at Fort Worth, Tex., has resigned and accepted a similar position with the San Antonio & Aransas Pass Ry.

Mr. J. W. Ambler has resigned the Chair of Mathematics and Geology at Roanoke College, Salem, Va., to become City Engineer and Superintendent of Water-Works of Winston, N. C.

Mr. P. L. McManus, Division Superintendent of the Southern Ry. at Charlotte, N. C., has been promoted to Assistant General Manager at Washington, D. C., to succeed Mr. R. A. Dugan.

Mr. Lucas R. Sorrs, Engineer of Tests of the New York, New Haven & Hartford R. R., has been promoted to Vice-President of the company's electric trolley lines, with headquarters at Boston, Mass.

Mr. K. C. Weedin, Construction Superintendent for J. G. White & Co. of New York City, has gone to San Juan, to supervise improvements and extensions to the company's electric railways in Porto Rico.

Mr. E. E. Young, Trainmaster of the Chicago, Burlington & Quincy R. R., at Denver, Colo., has been appointed Superintendent of the McCook Division of the road, to succeed Mr. E. A. Eaton, resigned.

Mr. Charles Dougherty, Superintendent of the Springfield Division of the Illinois Central R. R., with headquarters at Clinton, Ill., has resigned to become Assistant Chief Engineer of the Queen & Crescent Route, at Cincinnati, O.

Mr. Wm. P. Marshall has been appointed Division Engineer of the Western Division of the Norfolk & Southern Ry., in charge of the construction of the Raleigh & Pamlico Sound R. R. His headquarters are at Wilson, N. C.

Mr. F. C. Batchelder, Superintendent of the Baltimore & Ohio R. R. at Chicago, Ill., has been promoted to General Superintendent of the main line with headquarters at Baltimore, Md., to succeed Mr. C. C. F. Bent, appointed General Manager of the Baltimore & Ohio Southwestern R. R.

Mr. Arthur R. Denman has been elected President of the Board of Works of Newark, N. J.

Mr. Charles Beck, Chairman of the Board of Pensions, and formerly General Manager of the Illinois Central R. R., has been retired, having reached the age limit of 70 years.

Mr. Henry S. Wood, C. E., Executive Engineer of the Atlantic, Gulf & Pacific Co., and designer of most of the bridges and hydraulic dredges built by that company during the last twenty years, has resigned his position, and is considering new engagements. He is at present located at Room 1125, Park Row Building, New York City.

Mr. William J. Clark, General Manager of the Foreign Department of the General Electric Co., has been appointed by Governor Hughes as a delegate from New York State, to the National Convention for the Extension of the Foreign Commerce of the United States. This convention will be held at Washington, D. C., beginning Jan. 14.

Mr. J. W. Marden, Assistant Master Car Builder of the Boston & Maine R. R., has been promoted to Master Car Builder, to succeed Mr. John T. Chamberlain, resigned. Mr. C. H. Wiggin has been appointed Superintendent of Motive Power, to succeed Mr. Henry T. Bartlett, who is made Superintendent of the Mechanical Department.

Mr. Francis F. Coleman has been made Publicity Manager of the Lidgerwood Mfg. Co., 96 Liberty St., New York City. Mr. Coleman was for a time Editor of the "Electrical Age," before the late Louis Cassier bought that magazine, and has also been connected with the Westinghouse, the Allis-Chalmers and the Traylor Engineering companies' publicity departments.

Mr. John F. Creeden, of New York City, has been appointed by State Engineer Skene of New York, Division Engineer of the Eastern Division of the Erie canal; Mr. H. B. Brewster, of Syracuse, N. Y., Division Engineer of the Middle Division, and Mr. John T. Kelly, of Buffalo, N. Y., Division Engineer of the Western Division. The salary of these positions is $3,600 per year.

Prof. Robert L. Sackett, of Earlham College, Richmond, Ind., has been appointed Professor of Municipal and Sanitary Engineering at Purdue University, to succeed Professor Seastone. Professor Sackett has made several investigations of stream pollution and sewerage disposal for the state of Indiana, besides acting as consulting engineer for various public works. He will assume his duties at Purdue in September, 1907.

Mr. William R. Hill, M. Am. Soc. C. E., has been appointed Special Deputy State Engineer of New York at a salary of $5,000 per year. He succeeds Mr. Henry C. Allen. Mr. Hill was formerly Chief Engineer of Construction of the Syracuse (N.Y.) Water-Works, and later Chief Engineer of the Aqueduct Commission of New York City. In his new position he will have supervision of the building of the new barge canal, now under construction.

Mr. C. N. Payne has been elected head of the National Transit Co., to succeed the late Daniel O'Day. Mr. Payne became connected with the Standard Oil Co. in 1885, when he was employed to build and manage their natural gas lines. He became General Manager of the National Transit Co. in 1889, at the same time being elected Second Vice-President of the Buckeye Pipe Line Co., the Eureka Pipe Line Co. and the Southwest Pennsylvania Pipe Line Co.

Mr. Mace Moulton, M. Am. Soc. C. E., Consulting Engineer, 150 Nassau St., New York City, has been appointed Chief Engineer of the Millbrook Co., 30 Broad St., New York City. This corporation now controls the New York & Portchester R. R. and the New York, Westchester & Boston R. R., the two companies, which for a long time have been struggling for supremacy in the building of a four track high speed electric railway from the Harlem River, New York City, to points along Long Island Sound in New York State. Mr. Moulton will have entire charge of the construction of the road, and the whole line is expected to be in operation by Jan. 1, 1909. It is estimated that the construction and equipment will cost from $12,000,000 to $15,000,000.

Mr. James McCrea, First Vice-President of the Pennsylvania lines west of Pittsburg, has been elected President of the Pennsylvania system, to succeed the late A. J. Cassatt. Mr. McCrea was born at Philadelphia, Pa., May 1, 1848, and after graduating from the Pennsylvania Polytechnic College, he accepted a position as rodman on the Connellsville & Southern Pennsylvania R. R., in June, 1865. He became, in 1867, a rodman in the engineering corps engaged in building the Wilmington & Reading R. R. From September, 1869, to Mar. 1, 1871, he was employed as Assistant Engineer in the construction of the Bennett Branch of the Allegheny Valley R. R., when he became Principal Assistant Engineer of the Construction Department of the Pennsylvania R. R.

On Aug. 1, 1874, he was promoted to Assistant Engineer of the Philadelphia Division of this road, continuing in that office until Jan. 1, 1875, when he was appointed Superintendent of the Middle Division. He was transferred to Jersey City, N. J., in October, 1878, as Superintendent of the New York Division, and on May 1, 1882, was appointed Manager of the Southwest System. On Oct. 10, 1885, he was advanced to General Manager of all Pennsylvania lines west of Pittsburg. He was elected Fourth Vice-President of the Pennsylvania lines west of Pittsburg Nov. 1, 1887, Second Vice-President March 1, 1891, and First Vice-President May 1, 1891. He became a member of the Board of Directors on June 9, 1899.

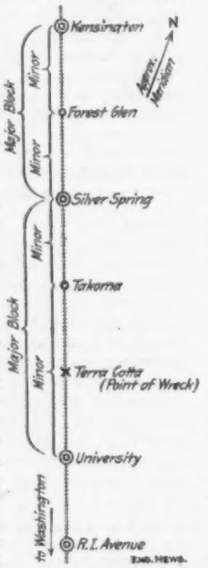
TABLE II.—Results of Duty Trials of Pumping Engines at Mahanoy City, Pa.

Pumping engine.	Worthington.	Snow.
Duration of trial, hours.....	9.4	10
Date of trial.....	9/17/'98	11/12/'06
Temp. of water pumped, deg. F...	62	41.8
Pounds of dry steam furnished the pumping engines per hour....	7,443	6,657
Steam pres., gage, at throttle, lbs.	118.4	141.5
Water pressure in force main at pump, lbs.....	355	373.2
Suction lift, in feet.....	7.48	4.3
Vertical distance between suction and discharge gages, ft.....	....	6
Standard duty, or foot-pounds of work done per 1,000 lbs. of steam consumed by the pumping engine	45,933,434	141,369,439
Capacity in gallons of plunger displacement per 24 hrs.....	1,360,246	3,106,277
Horse-power developed by steam cylinders:		
High-pressure cylinders.....	98.8	242.9
Low-pressure cylinders.....	109.2	245.8
Total indicated horse-power..	208.0	488.7
Pounds of dry steam used by the pumping engines per indicated horse-power per hour.....	35.78	13.62

THE REAR COLLISION AT TERRA COTTA, D. C.

In our last issue we briefly noted the rear collision of Dec. 30 on the Baltimore & Ohio R. R. at Terra Cotta, D. C., just outside the city of Washington, in which nearly 60 persons lost their lives and as many more were injured.

The circumstances of the accident have been under investigation by a coroner's jury during the week and also by the Interstate Commerce Commission. From the reports of the testimony given in the coroner's proceedings, the following statement has been prepared:



The Terra Cotta Wreck.
Diagram showing position of block stations.

The Metropolitan Branch of the B. & O. R. R. is a double track line for some distance out of Washington. Trains are operated under a telegraph block system. The block signal stations will be divided for the purposes of this statement into major and minor stations, a major station being open 24 hours with three shifts of operators, and a minor station working under one operator from 6:30 A. M. to 6:30 P. M. The stations at Kensington (see accompanying diagram), Silver Springs and University are major stations. The stations at Forest Glen and Takoma are minor stations. From 6:30 P. M. to 6:30 A. M. the minor stations close and the blocks lengthen to the distance between major stations. A weak point in the system appears to have been that the operators in the minor stations seemed to have no fixed time at which to shut down, sometimes leaving at 6:20 and sometimes at 6:40. At this time of the day, therefore, the engineers of passing trains appear to have been in some doubt whether to look for signals at the minor block stations or not.

On Sunday evening, Dec. 30, a dark and extremely foggy night, train No. 66, known as the "Frederick Local," left Washington Junction at 4:47 P. M. for Washington. This train, carrying the usual large local Sunday crowd, lost time at every one of the eight or more stops, so that at Terra Cotta, about 4 miles from the Washington terminal it was about 20 minutes late. At 5:27 P. M. there left Washington Junction on the same track an "extra" train No. 2120, running on special orders and made up of eight empty passenger coaches and Pullmans and the heaviest class of locomotive on the B. & O. This train had no stops to make and no schedule to follow. It appears that the engineer of the "extra" knew of the local being ahead of him, but, as usual, depended solely on the block signals for his right of way. At the time of the accident, however, the local, if on time, should have been in the station at Washington.

The local passed Takoma at 6:26 and a moment later stopped to take on passengers at Terra Cotta. The operator at Takoma set his block closed with a red signal, but at 6:31 the "extra" rushed by the signal and at 6:34 crashed into the local just pulling out of Terra Cotta.

The accident seems to have resulted from the extreme laxity of the block signal arrangements at that hour of the day when the wreck occurred coupled with the fatal coincidence of a fog so thick that lights not closely watched for could not be seen.

The engineer of the "extra" testified that he received at Kensington a white "clear track" signal and that Forest Glen was dark when he passed at 6:25, five minutes before its theoretical closing time. At Silver Springs, he said, was displayed a "double green," which meant that in the block ahead of him was another train about to pass to the other track by a cross-over. Now there is no cross-over between Silver Springs and Takoma but there is one between Takoma and University. This fact, taken in connection with the analogous station at Forest Glen being closed, led the engineer to conclude that Takoma had shut up and that the light shown at Silver Springs governed the road all the way to University. So he disregarded Takoma altogether. Had it been a clear night he would have seen the red "danger" signal displayed there and stopped; but the fog was so thick, he testified, that he could not see more than a few feet from his headlight. Why he did not slow up at Terra Cotta to look out for the train supposed to be using or about to use the cross-over did not appear in the testimony.

In contradiction to the engineer's statement, however, the operator at Silver Springs testified, and was supported by others, that he displayed for the "extra" train a white "track clear" signal. Such being the case, the engineer had no right to assume that Takoma was closed when he went by at 6:31, in view of the fact that the office often stayed open much later.

THE TYPHOID FEVER EPIDEMIC AT SCRANTON, Pa., numbered 984 cases and 67 deaths, so far as officially reported, up to noon of Monday, Jan. 7. The daily number of cases reported, including and since Jan. 1, have been as follows: 37, 22, 31, 11, 29, 5, 9. This shows a material falling off, as was expected from the fact that the Elmhurst Reservoir of the Scranton Gas & Water Co. has not been used during the three weeks ending Jan. 5. The State Department of Health has assumed control of the water supply outside the city limits, and has issued strict regulations for its sanitary protection, as well as instructions to its employees to abate every nuisance in the drainage area of the water company. Mr. F. Herbert Snow, M. Am. Soc. C. E., and F. M. Witherill, Jun. Am. Soc. C. E., Chief and Assistant Engineers of the State Department of Health, together with a number of medical inspectors, have been inspecting the water supply drainage area, some of them, we understand, since Dec. 15. Dr. Samuel G. Dixon, State Commissioner of Health, is reported as having stated unconditionally that inspections and analyses of the water supply show that it has been contaminated by sewage and is responsible for the epidemic.

BURST GAS MAINS cut off the natural gas supply of Cleveland, Ohio, Jan. 4. The mains, carrying gas from West Virginia to Cleveland, burst in a swamp about 35 miles south of Cleveland, the explosion destroying about 300 ft. of pipe-line, according to reports of the daily press. The two damaged lines carried about 60,000,000 cu. ft. of gas per day, and the shutting off of this supply caused much suffering in the hospitals and asylums and much inconvenience to hotels, restaurants, manufacturing plants and residents.

A REAR END COLLISION occurred on the Union Pacific R. R. at Brule, Neb., Jan. 2, between the "Overland Limited" and the "Los Angeles Limited." One passenger was killed and 13 injured, two fatally. The "Overland Limited" was nearly ten hours late and was running only ten minutes ahead of the "Los Angeles Limited," which was seven hours late. Both trains were expected to pass through Brule at full speed, but the "Overland Limited" was stopped to receive orders. It was just leaving the station and running at about four miles per hour, when struck by the following train. The rear brakeman had placed a lighted "fuse" 400 yds. back of the standing train upon being called but the engineer of the "Los Angeles Limited" unable to see it on account of a curve until it was late to avoid the collision.

A BUTTING COLLISION OF EXPRESS TRAINS the Chicago, Rock Island & Pacific Ry., near Volla Kan., Jan. 2, killed 32 passengers and injured as m others. The west-bound train known as the "Califor Fast Mail" was heavily loaded with passengers f Chicago, and carried one baggage car, one smoker, chair cars, one dining car, four tourist sleepers one Pullman. The east bound train, the "Chicago F Mail," was composed of two baggage cars, one smok two chair cars, one dining car, one tourist sleeper a one Pullman, but carried few passengers. The la train was only slightly damaged and did not leave track, but the baggage car, smoker, two chair cars a a tourist sleeper of the "California Fast Mail" were ditched and destroyed by fire. Most of the killed were Mexicans, traveling in the smoker of the ditched trai Many of the victims were consumed by the flames, som of the injured being burned to death. The collision is said to have been due to the telegraph operator at Volland failing to deliver orders, which he had received, for the "California Fast Mail" to pass the east bound train at Volland. It is stated that a block signal system had just been put in operation on this portion of the road on Jan. 1, the day before the accident.

AUTOMATIC STOPS as adjuncts to railway signals are apparently referred to in the following sent to Congress on Jan. 3:

> The Interstate Commerce Commission is credibly informed that automatic devices for preventing railroad collisions have been so far perfected as to justify thorough experimental tests of their practical usefulness. The Commission is of the opinion that such tests should be conducted by officials of the Government and at its expense.
>
> The Commission therefore recommends that suitable legislation be promptly enacted authorizing the Commission, or some other official body, to supervise and conduct experimental tests of such safety devices as appear to be meritorious, and that an appropriation be made, sufficient to secure the most competent experts and defray the other expenses incident to the project herein recommended.

A NEW BRIDGE LOOP to join the Manhattan and Williamsburg bridges was proposed at a meeting of the Rapid Transit Commission held Dec. 27, 1906. The proposal was submitted by Mr. John B. McDonald, builder of the New York subway. His plan is to construct a two-track subway connecting the two new bridges mentioned but avoiding the Brooklyn Bridge, with a short underground loop on the Manhattan side of the East River and a somewhat extensive circuit below the surface in Brooklyn. From the loop in Manhattan a spur would extend southward to Wall St. so that passengers whose destination was the extreme lower East Side would not be obliged to walk any considerable distance after arriving in the city. The loop as planned would be about eight miles long exclusive of the bridges, have 17 stations and a maximum carrying capacity of 20,000 persons per hour. Mr. McDonald said the loop could be built in three years at a cost of $10,000,000. Connections could be made with the present subway on the Manhattan side and with the East River tunnels on both sides of the river. This proposed loop would greatly relieve the Brooklyn Bridge of its heavy traffic and would kill the project of an elevated loop connecting the two present bridges. The members of the Board seemed favorably impressed with the plan and referred it to Chief Engineer George S. Rice for consideration and report without unnecessary delay.

A SUBWAY FOR TROLLEYS under Park Row, New York City, is recommended by Commissioner Stevenson in his report to the Board of Estimate, as a means of furnishing relief for the congestion at the Manhattan end of the Brooklyn Bridge. According to this plan, the surface cars of the Brooklyn Rapid Transit Co. would go down under Park Row to the three-cornered lot now occupied by the Staats-Zeitung building and other structures recently acquired by the city. Here there would be a series of eight loops built some distance below the street and above them a mezzanine floor accessible from the street by three stairways and having eight stairways leading downward to the track level, one to each loop platform. It is suggested in connection with this plan that all through elevated trains on Brooklyn lines be run to the Manhattan terminal during the rush hours, instead of only local bridge trains. Also, that the elevated terminal be built on two floors, one on the present level and the other where the present mezzanine floor of the bridge structure stands. This will provide a track and two platforms for each of the through elevated trains in Brooklyn, as the plan is to have four tracks on each level, two platforms for each track, and the tracks from the two levels coming together at Pearl St. These improvements will cost $3,250,000 and it is believed will increase the capacity of the bridge during the rush hours about 25%.

Obituary.

Andrew Spence, a retired Architect of New York City, died at his home in that city Jan. 3, aged 80 years.

Samuel B. Randall, the founder of the Hancock Inspirator Co., died at his home in Dorchester, Mass., Jan. 5, aged 82 years.

Perry A. Gibson, General Manager of the McKeesport, Connellsville & Greensburg Street Ry., died at Pittsburg, Pa., Dec. 30.

William G. Wilson, President and Treasurer of the Republic Mining & Manufacturing Co., of Philadelphia, died at his office in that city Dec. 29, of heart disease, aged 64 years.

Joseph K. McCammon, United States Commissioner of Railroads during President Hayes' administration, died at his home in Washington, D. C., Jan. 2, aged 61 years. He was born at Philadelphia, Pa., and was a graduate of Princeton University, class of 1865.

Oliver B. Green, President of the Green Dredging Co., died at his home in Chicago, Ill., Dec. 29, aged 81 years. He was born at Worcester, Mass., and was employed as civil engineer on the first surveys of the New York Central & Hudson River R. R. and the Mississippi Central R. R.

James Henry Gerry, inventor of the self-winding clock and the gravity escapement in clocks, died at his home in Brooklyn, N. Y., Dec. 30, aged 78 years. He was a watchmaker by trade, and for 15 years previous to his retiring from business, in 1904, was Superintendent of the Self-Winding Clock Co., of Brooklyn.

George H. Goddard, a pioneer surveyor of California, died at his home in Berkeley, Cal., Dec. 27, aged 80 years. He was born in England and educated at Oxford University. He had lived in California since 1849, and surveyed the State boundary line between Nevada and that State. Many of the passes now traversed by railways were first surveyed by him.

Arthur Mills, Vice-President and General Manager of the Merchants' Despatch & Transportation Co., died suddenly at New York City, of heart disease, Jan. 1, aged 56 years. He was a graduate of Harvard University, class of 1872, and had spent his active life in the freight traffic department of various railways. Since May 1, 1898, he had been Vice-President and General Manager of the Merchants' Despatch Co.

Winfield Scott Keyes, M. Am. Inst. M. E., Consulting and Mining Engineer, San Francisco, Cal., died at his home there Dec. 27. He was born at Brooklyn, N. Y., Nov. 17, 1839, and graduated from Yale University with the class of '60. He then took a three years' course at the School of Mines, at Freiburg, Saxony. During the Centennial Exposition at Philadelphia in 1876, he was a member of the Board of Judges, and in 1878 was an Honorary Commissioner to the Paris Exposition. Mr. Keyes was the joint inventor of the Keyes and Arents' automatic tap for molten metals. He was often retained in mining suits as an expert, and contributed many articles to the mining and scientific journals, besides writing several books. Among his books are "Resources of California" and "Resources of Montana." He was General Manager of the Pan-American Development Co., whose mines are in Mexico.

Robert H. Sayre, formerly Second Vice-President of the Lehigh Valley R. R., died at his home in South Bethlehem, Pa., Jan. 4, aged 82 years. He was born in Columbia County, Pa., Oct. 13, 1824, and was educated in the public schools and by private tutors. In 1840 he entered the engineering corps engaged in enlarging the Morris Canal in New Jersey, and later was employed on the Lehigh Canal. From 1844 to 1845 he was employed on the surveys and construction of the Back Track R. R. between Mauch Chunk and Summit Hill, N. J. In 1852 he became Chief Engineer of the Delaware, Lehigh, Schuylkill & Susquehanna R. R. (now Lehigh Valley R. R.), serving until 1882. He was then elected President of the South Pennsylvania R. R., later becoming Second Vice-President of the Lehigh Valley R. R., in charge of the traffic and engineering departments. Mr. Sayre was also one of the promoters of the Bethlehem Iron Co., and was elected a director in 1862, General Manager in 1886 and Vice-President in 1891. He was a trustee of Lehigh University. The town of Sayre, where the Lehigh Valley R. R. Co. established large shops some years ago, was named in his honor.

Colonel Charles H. Irvin, a well-known civil engineer of the West, died at Boise, Idaho, Nov. 22. He was born at Yorkshire, England, Feb. 23, 1832, and was educated at Kings College, London, for "Holy Orders." He, however, decided to take up the work of a civil engineer and studied with some of the most able men of that time. At the age of 19 he came to the United States and secured a position with the New York Central & Hudson River R. R. Later he became associated with Mr. Albert C. Tracey, who had charge of the building of a suspension bridge at Niagara Falls, N. Y. At the building of the Denver & Rio Grande R. R. he was made Assistant Engineer, and while thus employed originated the plans for the now celebrated "Hanging Bridge" in the Grand Canyon of the Arkansas. In 1861 he enlisted in the 9th Michigan Infantry, as First Lieutenant, but was soon promoted to Captain and placed in charge of the Quartermaster's Department of the Army of the Cumberland, on the staff of General Thomas. In addition to the duties of this position he was given full charge of the building of the fortifications at Nashville, because of the illness of General Donaldson, the officer in charge of the Engineering Corps. Owing to the prompt and efficient service of the Quartermaster's Department of the Cumberland during "Sherman's March to the Sea," Captain Irvin was commissioned a full Colonel.

In 1882 Colonel Irvin projected the Santa Fe, Texas & Northern R. R., which was to run from El Paso to the Gulf of Mexico. Some 30 miles of this road were built, but due to the financial panic of 1884 the project had to be abandoned, and was never completed. He removed to Idaho in 1890 to represent Mr. W. C. Bradbury's interests in the building of the New York Canal. Later he was employed in engineering and building the Payette Canal and managing the Phyllis Canal. A few days before his death he completed in conjunction with Messrs. Walter C. Graves and A. J. Wiley an exhaustive report upon the proposed new water-works system for the City of Boise, Idaho. Colonel Irvin had been an invalid for some time, due to a partial stroke of paralysis, but up to the time of his death was continually working on engineering problems.

ENGINEERING SOCIETIES.

COMING MEETINGS.

WOOD PRESERVERS' ASSOCIATION.
Jan. 15. Annual Meeting at Memphis, Tenn. Secy., C. W. Berry, Laramie, Wyo.

AMERICAN SOCIETY OF CIVIL ENGINEERS.
Jan. 16-17. Annual Meeting at New York City. Secy., C. W. Hunt, 220 West 57th St., New York.

NORTHWESTERN CEMENT PRODUCTS ASSOCIATION.
Jan. 16-18. Annual Convention at St. Paul, Minn. Secy., Martin T. Roche, 410 Pioneer Press Bldg., St. Paul, Minn.

INDIANA ENGINEERING SOCIETY.
Jan. 17-19. Annual Meeting at Indianapolis. Secy., C. C. Brown, Commercial Club Bldg., Indianapolis, Ind.

THE ENGINEERS' CLUB OF PHILADELPHIA.
Jan. 19. Annual Meeting at Philadelphia. Secy., Walter Loring Webb, 1122 Girard St., Philadelphia, Pa.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS.
Jan. 22-24. Annual Meeting at New York City. Secy., W. M. Mackay, P. O. Box 1818, New York City.

OHIO ENGINEERING SOCIETY.
Jan. 22-24. Annual Convention at Columbus, Ohio. Secy., E. G. Bradbury, 85 North High St., Columbus, Ohio.

ILLINOIS SOCIETY OF ENGINEERS AND SURVEYORS.
Jan. 23-25. Annual Meeting at Peoria, Ill. Secy., E. R. Tratman, 1636 Monadnock Block, Chicago, Ill.

CANADIAN SOCIETY OF CIVIL ENGINEERS.
Jan. 29. Annual Meeting at Montreal. Secy., Prof. C. H. McLeod, 877 Dorchester St., Montreal, Quebec.

THE NATIONAL BRICK MANUFACTURERS' ASSOCIATION.
Feb. 4-16. National Convention at St. Louis, Mo. Secy., Theo. A. Randall, Indianapolis, Ind.

NEW ENGLAND GAS ASSOCIATION.
Feb. 21. Annual Meeting at Boston, Mass. Secy., N. W. Gifford, East Boston, Mass.

ASSOCIATION OF ONTARIO LAND SURVEYORS.
Feb. 26. Annual Meeting at Toronto. Secy., Killaly Gamble, 405 Temple Bldg., Toronto, Ont.

AMERICAN RAILWAY ENGINEERING AND MAINTENANCE OF WAY ASSOCIATION.
Mar. 19-21. Annual Meeting at Chicago, Ill. Secy., L. C. Fritch, 1562 Monadnock Block, Chicago, Ill.

ENGINEERING SOCIETY OF THE CAROLINAS.—This society was organized a short time ago at Charlotte, N. C. The membership will be drawn from the States of North and South Carolina. Its object, requirements for membership, etc., are similar to those of like organizations. Mr. Daniel A. Tompkins is President; Messrs. Erwin W. Thompson and William States Lee, Jr., Vice-Presidents; Mr. Clough W. Sims, Treasurer, and Mr. Curtis A. Mees, Secretary. Headquarters of the society are at Charlotte, N. C.

MINNESOTA SURVEYORS AND ENGINEERS SOCIETY.—The annual meeting of the Society will be held at St. Paul, Minn., in the rooms of the State Highway Commission, in the new Capitol, Jan. 17. Besides the regular business and election of officers, the following papers will be read: "Concrete Bridges," C. A. P. Turner; "Good Roads Labors," Prof. W. R. Hoag; "Sewage Disposal for Flat Districts," Thos. E. McGilvary; "Irrigation," Geo. Sublette; "Compressed Air from Water," J. E. Hill, and several other papers of local interest.

THE ENGINEERS' CLUB OF CENTRAL PENNSYLVANIA.—The annual meeting of the club was held in the club rooms Jan. 8, at 8 p. m. The officers elected at the previous meeting were installed, and at the close of the business session. Prof. Mansfield Merriman gave an informal talk on "The Surface Curves of Rivers." The club holds a joint meeting with the Board of Trade of Harrisburg, Pa., on Thursday evening, Jan. 10, when Mr. A. Frederick Collins, of New York City, will deliver an illustrated lecture and demonstration on "Wireless Telegraphy and Telephony."

AMERICAN SOCIETY OF MECHANICAL ENGINEERS.—The spring meeting will be held at Indianapolis, May 28-31, inclusive. As this city is the second largest center of the automobile industry in the United States, considerable attention will be given at the meeting to the mechanical engineering of the automobile. The meetings committee will be pleased to receive offers of technical papers on this subject, but no papers will be received after April 15, as all papers must be distributed to the membership of the society at least 30 days in advance of the meeting at which it is to be read.

CENTRAL ELECTRIC RAILWAY ASSOCIATION.—The annual meeting will be held at the Claypool Hotel, Indianapolis, Ind., on Jan. 24. The business session and election of officers will occupy the morning, and in the afternoon the following subjects will be discussed: 1, Cost of power for rental purposes; 2, Does it pay to develop a demand for renting power; 3, The best type of car for long-distance travel; 4, The lighting of street and interurban cars; 5, The handling of accidents and claims. Many interurban lines are expected to run long-distance through cars into Indianapolis for this occasion. Mr. Edward C. Spring is President, and Mr. W. F. Milliholland, of Indianapolis, is Secretary and Treasurer.

ROADMASTERS AND MAINTENANCE OF WAY ASSOCIATION.—The executive committee has prepared the following list of subjects for papers and committee reports to be presented at the annual convention: 1, Maintenance of line and surface in winter; 2, Weed burners and other devices for destroying vegetation along the track; 3, Wrecking outfits, organization and working; 4, Cost of ballasting old track and renewing ties; 5, Organization, work and cost of relaying rails; 6, The oiling of ballast and roadbed; 7, Why efficient track work is skilled labor; 8, Special construction on the Cincinnati Southern Ry. Mr. W. E. Emery, West Chicago, Ill., is Secretary.

MONTANA SOCIETY OF ENGINEERS.—The twentieth annual meeting will be held at Butte, Mont., Jan. 10-12. Thursday and Friday will be employed in making visits to various plants, mines, etc., about Butte. Sessions for the conducting of general business, election of officers and reading of papers will be held Saturday, followed by a banquet in the evening. The officers nominated for the ensuing year are as follows: President, Mr. Edward C. Kinney; First Vice-President, Mr. Archer E. Wheeler; Second Vice-President, Mr. Arthur H. Wethey; Secretary and Librarian, Mr. Clinton H. More; Treasurer and Member of the Board of Managers of the Association of Engineering Societies, Mr. Samuel Barker, Jr.

INDIANA ENGINEERING SOCIETY.—The next annual convention of the society will be held at Indianapolis, Ind., Jan. 17-19. Among the papers to be read at the meeting are the following: "The Design of a Successful Gasoline Engine," L. O. Danse; "A Reinforced Concrete Sewer," M. A. Morris; "Estimates for Steel Highway Bridges," B. F. Nesbit; "Interurban Railway Engineering," R. P. Woods; "Advantages of Electrical Inspection," F. R. Daniel; "The Track Elevation Plans for Indianapolis," Chas. C. Brown and B. J. T. Jeup; "Electric Car Braking," Prof. H. T. Plumb. The social features of the convention will include a banquet, a smoker and excursions to points of interest in and about Indianapolis.

PUBLIC UTILITIES ASSOCIATION OF INDIANA.—The above association was organized at Indianapolis, Ind., Dec. 28, when constitution and by-laws were adopted. The membership is to be drawn from the managers of electric and water power plants operating in the State. The object of the association is stated in the constitution as follows:

> To bring into closer touch the managers and officials of these plants in a social way, but more particularly to promote discussion on the many questions of vital interest in the management and operation of light, power and water plants.

The officers elected are: President, Mr. B. W. Hubbard, Mooresville; Vice-President, Mr. W. S. Meade Spencer; Secretary, J. A. Shank, Peru.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.—The 213th meeting will be held in the Auditorium of the Engineers' Building, 33 West 39th St., New York City, Jan. 25, at 8.15 p. m., when a paper on "Substitution of the Electric Motor for the Steam Locomotive," by Messrs. Lewis B. Stillwell and Henry St. Clair Putnam, will be presented. The paper covers the following points: 1. Presentation of certain facts established by experience in the operation of elevated, subway and interurban lines by electricity. 2. Discussion of comparative cost of operation by steam and electricity applied to railways in operation, and including both passenger and freight service. 3. The importance of standardizing electric railway practice. 4. The question of frequency in the operation of railways by alternating current. Members of the American Society of Civil Engineers, the American Institute of Mining Engineers, the American Society of Mechanical Engineers, the New York Railroad Club, and the Transportation Club, are cordially invited to attend this meeting.